ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 180 No. 4672 LONDON, FRIDAY, AUGUST 12, 1955 PRICE 2s.

UNIVERSITY OF MICHIGAN
AUG 31 1955
ENGINEERING LIBRARY

MAKING STRAINER CORES

Quick testing for every make of relay or meter

"Plug-in" testing, previously possible only with drawout patterns, is now made available for relays or meters of any type or manufacture, with the use of the new 'ENGLISH ELECTRIC' universal test block.

'ENGLISH ELECTRIC'
universal test block

THE ENGLISH ELECTRIC COMPANY LIMITED, QUEENS HOUSE, KINGSWAY, LONDON, W.C.2.

Meter, Relay and Instrument Division, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL ACCRINGTON

RL39HS

ENGINEERING

An Illustrated Weekly Journal

Vol. 180 No. 4672 AUGUST 12, 1955

Leading Article
National Service Without Exemption? 193

Weekly Survey
Threat to Steel Supplies 194
More Orders for Petroleum Plant 194
Petroleum Limited 194
American Shipping and Shipbuilding 194
Canadian Recovery 194
The Millionth Volkswagen 195
Spreading the Load 195
Is the driver awake? 195
Dispatch from Geneva 195

Principal Articles
Some Aspects of the American Aircraft Industry: Impressions of a Visit to Canada and U.S.A. 196
Nuclear Power in Canada 198
Unwilling Partners: The Employer's Duty to Enforce Safety Measures 203
Broadcasting 1954-55: V.H.F. Reinforcement and Television Experiments 204
The Art of Heating and Ventilating 205
Australian Aeronautical Research Laboratories: Work on High Temperature Alloys and Turbines 208
Heat Losses of Locomotive Boilers: Measuring the Effects of Radiation and Exhaust Steam Injectors 209
Bending of a Straight Beam Under Transverse Loading: Impulse and Step Functions in Elementary Problems 211
Controlled Superheat in an Integral Furnace Boiler 213
Avoiding Temperature Shocks in Steam Turbines: "Superheat Boost" Reduces Re-Start Time 214
Automatic Can-Filling Machine: High-Speed Operation Controlled Photo-Electrically 216
Multi-Purpose Woodworking Machine: Spindle Moulder with Single-Lever Control 216
Drilling and Boring from All Angles: Machine with 30-500 r.p.m. Spindle Speeds 217
Pressure-Balanced Relief Valve 217
Safety on the Railways: Driver's Vigilance Automatically Checked 218
Fishery Research Trawler "Sir William Hardy": Diesel-Electric Propelling Machinery 220
Smoke Control in a Medium-sized Boiler 222
General-Purpose Machine Tool 222

Letters to the Editor
Conveying Information Quickly 197
Maintenance Handbooks 197

Obituary
Lt.-Col. H. S. Rogers, C.M.G., D.S.O. 196
Mr. Alistair M. Gibb 196

Book Reviews
The Life of Lord Nuffield 201
Mastering Momentum 201

Notes
Institution of Public Health Engineers 201
Reclaiming Land at Shell Refinery 207
Road Construction in the Scottish Highlands 211
Loading of Highway Bridges 214
A New House Journal 215
Flame Cleaning of Fouled Tubes 222
British Association Meeting at Bristol 223
High-Altitude Rocket Research 223
Radio-Astronomy at Cambridge 223

Personal 200, Commercial 200, Contracts 200, Trade Publications 202, Books Received 202, Launches and Trial Trips 217, Labour Notes 224.

★ ★ ★

Published every Friday by Engineering Limited 35 & 36 Bedford Street, Strand, London, W.C.2 TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

NATIONAL SERVICE WITHOUT EXEMPTION?

Two years' compulsory National Service in one of the Forces is an unfortunate necessity but a fine discipline. It does not appeal to one's sense of patriotism or duty as strongly as did voluntary service in war; to a young man intent on hard work and study it may appear to be a deplorable, time-consuming, energy-sapping obstruction, and to an employer with more work in prospect than men available it is a competitor with an unfair advantage.

Current discussion on the subject can be crystallised conveniently into two opposing views: everyone, irrespective of occupation, should be liable to do National Service in one of the Forces, and the period of service should be the same for everyone; opposed to that is the view that to those who are already exempt, notably coal miners, merchant seamen, and agricultural workers, there should be added other groups—scientists, technologists, and teachers. In every case there is a shortage of the particular craft or profession for civilian requirements, and it seems a convenient and economical plan to divert the chosen classes from one form of National Service to what is considered to be another.

There is something to be said for both sides. The latest proposals for the exemption or redirection of scientists have drawn protests from two groups. The first are those who object to the discrimination in favour of certain types of ability. An arts graduate is as valuable a man as a science graduate, but just because there happens now to be a shortage of science graduates, the arts graduate must serve in the Forces for both of them. The second group of objectors are those who are working as civilian scientists, and who see in the seconding of R.E.M.E. soldiers to the Atomic Energy Authority a move to reduce the value of the civilian scientists by introducing "cheap forced labour."

In defence of the second view, it is said that the use of scientists to peel potatoes and stamp on a barrack square for two years (a colourful but probably unjust exaggeration) is a scandalous waste of trained men. Since the nation is short of trained men, they should be put into the place where they can do most good. Deployment of human resources is as important in peace as in war, and there can be nothing wrong in extending exemption and deferment to those classes of labour in short supply.

To adopt an intermediate position between the two opposing views, it could be suggested that everyone should be liable for a period of National Service to learn the basic skill of a sailor, soldier or airman. After that period, say six months, he could either be drafted to an operational unit for a period of eighteen months, or seconded, if he had the necessary qualifications, to a Government or other approved scientific establishment for a similar period. In this way all would meet together for a time, and there would be a feeling of comradeship and equal sacrifice. The six months' break would do few if any scientists any harm, and those who had to remain in the Forces would not feel that the duty fell entirely on them.

But the Service departments should be asked to answer some relevant questions. They are given nearly all fit young men for a period of two years. These men are conscripted: the Service departments do not have to compete for them in an open market, as do other Government departments and every industry. National Service men are a representative cross-section of their generation, ranging from some who cannot read to brilliant young men whom any employer would be glad to have. Yet it seems that the Services cannot fully employ all those who are at the top of the intellectual scale. How can that be? Are the Services equipped with Eighteenth Century weapons, requiring only quarter-masters and armourers for maintenance? On the contrary, the Services are equipped with some of the most advanced products of science and engineering. If the Navy, the Army and the Air Force are to be ready to use this equipment with full effect; if, in peace, with limited quantities of equipment, they are to be always in a state of trained readiness and able to absorb a sudden influx of men and material in an emergency—then, surely, they should need a higher proportion of well educated men than is required even in civilian life.

It is impossible to avoid the conclusion that the Services cannot make full use of conscripted brains because they have yet to learn how to make full use of modern armaments. The Navy may be an exception, partly because its National Service element is relatively small, and partly because the Admiralty has succeeded in retaining responsibility for the development and design of its own equipment. But the Army and the Air Force rely on the Ministry of Supply for most of this work, with a small number of regulars contributing the Service element. It would be difficult, but not impossible, to employ educated National Service men on problems connected with the development of new weapons and the assimilation into Service organisation of up-to-date weapons. The fact that this is not being done, or is not being done on a sufficient scale, is proved by the complaints of wasted ability among National Service men.

Weekly Survey

Cover Picture: *Holes and recesses in castings are formed by cores assembled in the mould. The cores shown on our cover, however, are used for a special purpose. They are strainer cores which are placed in the runner cups of moulds to prevent slag and other impurities from entering the mould with the molten iron. In this case the cores have been made by hand.*

* * *

THREAT TO STEEL SUPPLIES

The steel industry's output was not seriously affected by the rail and dock strikes, but we are now reminded that the more indirect results of the strike have still to be felt. The disruption caused to ore shipment schedules in particular, as well as other effects such as the loss of marginal pig-iron supplies, an unbalanced erosion of stocks of steel-making materials, and a distortion of the pattern of finished steel deliveries, make it unlikely now that the anticipated crude steel output of 20 million tons will be achieved this year. The Iron and Steel Board have said that there still remains a prospect of producing about 19¼ million ingot tons compared with just over 18¼ million tons last year, but any complacency there might be about the situation will have been removed by a statement last week by Sir Andrew McCance, deputy chairman and joint managing director of Colvilles. His blunt warning was that steel output in Scotland will be reduced next winter unless special steps are taken immediately to replenish stocks of iron ore. The rail strike interfered with summer stock-piling and the ban on overtime by Clyde tugboat-men during the past two months has made matters worse.

Although steel plants likely to be the most seriously affected are those which depend more than the average on imported ore supplies, the industry as a whole will feel a shortage. It had hoped to increase its imports of ore by nearly a million tons this year, to 12·6 million tons, in order to meet the anticipated expansion in pig iron output from four new blast furnaces, at Shotton, Margam, Ebbw Vale and Barrow, which will require about 2 million tons of ore annually if they are to be worked to full capacity. In the first six months of the year iron ore imports fell by 150,000 tons and consumption of imported ore rose by 65,000 tons while the production of home ore has remained stable.

Though the situation may not be as critical as Sir Andrew McCance would have us believe, it will certainly be difficult to increase imports sufficiently before the ports at Wabana, Labrador, and at Lulea, Sweden, close for the winter. Shipping is in short supply, due mainly to the heavy imports of coal, and freight rates are rising. It may be of course that much more could be done, and perhaps will be done, to raise the economic rate of extraction of home produced ores—a matter now under review by the Iron and Steel Board.

* * *

MORE ORDERS FOR PETROLEUM PLANT

The chairman's report on the work of the Council of British Manufacturers of Petroleum Equipment (CBMPE) reflects the considerable improvement that has taken place in the demand for oil equipment and materials. Total orders received during the first quarter of 1955—£32·8 million—were 40 per cent. greater than the corresponding figure for the last quarter of 1954 and at an annual rate over 60 per cent. greater. Items which show an increase substantially higher than the average include prime movers and compressors (300 per cent.); specialised equipment for oil drilling and production (90 per cent.); tubular goods, pipe fittings and valves (57 per cent.); pumps (92 per cent.); and electrical equipment, including motors, generators, etc. (62 per cent.). On the other hand, orders for oil refinery equipment show only a modest increase and those for all types of transport equipment and for machine tools show a decrease. The general picture conveyed by the figures is one of great activity in the building of pipelines while investment by the oil companies in oilfield equipment continues to increase. The figures certainly bear out the statement of the CBMPE retiring chairman, Mr. Douglas Wilson, made at the 1954 meeting of the Council, that "the petroleum industry, far from being a declining business, offers enormous opportunities" at a time when many people were prophesying a long period of falling demand.

An interesting figure in the report is that for annual expenditure on the maintenance and repair of British-owned refineries in the U.K. and overseas, estimated, on the basis of an assumed total investment of some £250 million, at £6¼ million. Mr. Wilson points out that this sum does not include expenditure on modernisation and expansion, and concludes that demand for the services of refinery plant manufacturers will continue at a high level.

The technical adviser's report discusses the progress of automatic operation in the oil industry, and gives the example of an isolated compressor station built by the Gulf Interstate Gas Company at a cost of 730,000, dols. which comprises a centrifugal compressor unit powered by a gas engine of 3,500 brake horse-power, and operated entirely without any manpower. This type of development, and others tending in the same general direction, are becoming typical of the needs of the oil industry, to reduce costs and the hardship of operatives in lonely situations.

* * *

PETROLEUM LIMITED

The Esso Petroleum Company's Annual Review for 1954 is quite outstanding. Two statements contained in it are of considerable interest. The first relates to the part played by oil in the supply of the world's demand for energy; in 1954 the figure was 37 per cent. and during the last 16 years petroleum and natural gas—and to a much lesser extent water power—have been responsible for the entire quantitative increase in the world's energy supplies. Coal consumption in 1954 was the same as in 1938. But, the report states, "proven reserves in the free world are now estimated at 147,000 million barrels (say, 30 years' consumption) of which the Middle East accounts for two-thirds." Yet in ten years, one-third of the way towards the exhaustion of proven oil reserves, the contribution of atomic power to this country's energy needs is unlikely to exceed 2 per cent.; last year oil contributed 14 per cent. of total energy consumed, "almost double the 1938 proportion but still only a quarter of the figure in the United States." This underlines only too clearly the importance of our coal industry over the next half century and the crucial need to tap other sources of energy before mineral fuels run out.

The second item of interest is a statement concerning the company's expansion policy (£49 million have been spent since 1948 on tankers, the Fawley refinery and marketing plant and equipment). The company's chairman and managing director, Sir Leonard Sinclair, said in his message to employees: "... there lie in front of this company prospects which in the next ten years can lead to as great an expansion as there has been over much of the previous life of the industry," and, underlining the company's need for capital, he spoke of a sum "even much greater than we have ever used before and by which alone we can build the extra ships, expand the refinery, increase the storage capacity and provide more and better distribution equipment ..." During the past year the emphasis has been on increasing the utilities, such as salt water for cooling purposes, fresh water for steam generation and electric power, "to lay the necessary foundation for further expansion of the refinery, as the need arises." All this suggests that the oil companies are on the threshold of a further major round of refinery expansion, and Esso already have plans for the construction of a Hydroformer—not yet used in Britain—which will make possible the manufacture of high-octane petrol from crude-oil fractions, thus reducing the need for middle distillates (for which there is an increasing demand) to feed the catalytic-cracking plant.

* * *

AMERICAN SHIPPING AND SHIPBUILDING

A recent announcement from Washington about the programmes of the American shipping lines indicates that they will spend over £1 million within the next few years on the modernisation and expansion of their fleets. The committee of the American Steamship Lines described this as "the largest peace-time ship replacement programme in the nation's history," designed to make American merchant shipping competitive with other world tonnage. About 40 per cent. of the total cost of the programme will be supplied by the U.S. Government in the form of subsidies to shipyards and shipyard labour. This is expected to put an end to the slump that has afflicted American shipyards in the past three years, despite heavy ordering by U.S. shipping lines. Nearly all these orders went to foreign yards, whose costs were as much as 40 per cent. lower than those of American builders. From the end of the war until June this year U.S. shipping companies had ordered 302 vessels, totalling 6·1 million deadweight tons, from foreign yards. At the beginning of June, 15 merchant ships were being built in U.S. yards compared with 423 in Britain and 241 in Germany; 90 ships were being built in foreign yards for American owners.

In view of the obsolescence of the U.S. merchant fleet—80 per cent. of ships in use are over 20 years old—the renewal programme has come none too soon if U.S. shipping lines are to compete on world trade routes. When the programme gets under way a large number of ships built during the war will be scrapped. In order to get over the difficulty of having to pay high wages a number of American shipbuilders moved to countries where wage rates are low. National Bulk Carriers, Inc., closed down its Virginia yard and moved to Kure, Japan, and Gibbs Corporation of Jacksonville moved to the Dominican Republic where the labour costs are 15 cents an hour compared to 1·80 dollars in their previous location. They are, however, making themselves very unpopular with U.S. unions and it is unlikely that many companies will follow their example.

The new home building programme is not expected to affect seriously the level of orders placed with foreign yards. The American Bureau of Shipping's report to their semi-annual meeting last month indicates that shipbuilding activity is likely to continue high throughout the world. The decline in tanker orders—likely to be temporary—is being offset by a large increase in orders for bulk carriers. Tramp vessels are being ordered in large quantities and, in general, the prospects of shipbuilding in this country and elsewhere have never been brighter.

* * *

CANADIAN RECOVERY

This year the spring brought to Canada a much more favourable economic climate as well as good weather for outdoor activity. The June *Review* of the Bank of Nova Scotia notes "a significant revival of expansionary influences" and a strong rise in industrial production which was higher in May than ever before at that time of the year. The recovery is attributed largely to the U.S. boom, which has led to a better demand for Canadian exports and a widespread revival of business confidence. High vehicle production in the United States has stimulated the demand for Canadian base metals, the rising

level of U.S. construction has attracted large amounts of Canadian lumber and the upturn in U.S. consumption of pulp and paper has greatly strengthened the world markets for these important Canadian products. Some industries, however, remain depressed. Coal is suffering from the competition of other fuels, the demand for farm machinery and railway rolling stock is still weak, and employment has been contracting in defence industries such as aircraft manufacture and shipbuilding. Nor has farming, particularly the sales of grain from the Prairies, fully recovered. Despite these weaknesses, average weekly wages and salaries have continued to rise and consumer income so far this year has been 4 to 5 per cent. higher than in 1954.

This improvement in the Canadian economy may arrest the decline in British exports to that country, particularly as there is an urgent need for dollars to finance British purchases of Canadian exports. The value of British exports to Canada dropped by 10 per cent. during the first half of the year, machinery and cars showing the biggest decline. This stands in painful contrast to the rise in Canada's overall imports (8 per cent. above the 1954 level) and to the performance of Germany. The drop in car exports—one-third below the corresponding 1954 figure—is the most worrying, as sales during this period have been very high. Some of the trouble seems to arise from the inability or unwillingness of British manufacturers to send cars to the Canadian market, with the exception of Ford Consuls which have been selling in greater numbers than ever before.

The Canadian authorities are critical of British manufacturers, on the ground that they do not try to export their goods. Whether this is so or not there is a pressing need for British engineering to go all out to reverse the present trend, and the new Canadian prosperity is a fine opportunity.

* * *

THE MILLIONTH VOLKSWAGEN

In a blaze of publicity, the millionth car to be built at the Volkswagen Company's works at Wolfsburg since the end of the war rolled off one of the three assembly lines. This car, finished in gold, will be exhibited throughout the world to cap what is probably the most skilful and sustained sales effort by any company during the last decade. Dr. H. Nordhoff, the managing director, took the opportunity of making a statement on future prospects and on the conditions under which the company goes forward to the two millionth car at a daily rate shortly to be increased to 1,300.

First, design: the outward appearance will not change but improvements will continue to be made; already the new cars have wider front seats, more leg room for the rear passengers, a large front luggage compartment and twin exhaust pipes which give more power and make the engine quieter. Preparations have been made, however, to have stylish elongated bodies of the Italian Ghia design fitted as a (costly) alternative. Second, exports: 400,000 of the million have been sold outside Germany and 58 per cent. of output is currently exported. But Dr. Nordhoff complained that, while three-quarters of British car exports go to duty-free markets, his cars must pay duty everywhere. Third, labour: he doubted whether the German Federation of Trade Unions would get their demand for a 40-hour 5-day week granted during the next four or five years, if ever. The company's policy is to increase wages whenever possible and to work shifts (two at present). Fourth, materials: more than half the coal used at Wolfsburg next winter would be foreign and steel would also have to be imported, because Germany did not produce enough of the right type and quality for the company's requirements. Fifth, prices: price reductions of £13 for the standard model and £21 for the de-luxe were announced but will apply to the German market only, where competition is becoming acute.

Just before Dr. Nordhoff's speech it was announced that German car manufacturers plan to invest £80 million in expansion of their plants, which will bring capacity to about 1·2 million units or approximately equal to present British production. It is comforting indeed that world demand for cars appears insatiable and has so far expanded faster than world output.

* * *

SPREADING THE LOAD

There should be no power cuts next winter, unless weather of extreme severity should coincide with the winter peak loads. The Electricity Sub-Committee of the Joint Consultative Committee, whose report was published last week, consider that there should be sufficient plant capacity available nationally next winter to avoid disconnection of supplies in an average cold spell, although voltage reduction will still be necessary. In fact the prospects for next winter are slightly better than they were last year, when no special load-spreading measures had to be taken.

The Sub-Committee's recommendations, which have been accepted by the Government, are substantially the same as last year. Regional Boards for Industry are to continue to have the discretion to make load-spreading arrangements in the light of conditions in their area and the Load Spreading Committees of the Boards will therefore remain in being. Winter peak hours are now re-defined as 4 p.m. to 5.30 p.m. in November, 8 a.m. to 12 noon and 4 p.m. to 5.30 p.m. in December and January, and 8 a.m. to 12 noon in February. Domestic and commercial consumers will be asked to economise during these times. In addition, "at their discretion and in consultation with Local Area Electricity Boards," Regional Boards are asked to encourage the use of private generating plant to keep down the winter peak load.

The Sub-Committee conclude that the experience of the past two winters has shown that the necessity for industrial load spreading is no longer "a normal expectation of the winter months" and therefore do not propose to issue further reports. But the British Electricity Authority are spending nearly £200 million a year on new power stations, transmission lines and distribution equipment, and the time is not far off when demand will require to be stimulated rather than contained.

* * *

IS THE DRIVER AWAKE?

With the introduction of electric traction on railways it became the practice to adopt one-man driving and fit the so-called "dead man's handle." The driver has to maintain a knob in the controller handle depressed and if, for any reason, he ceases to do so the current is automatically cut off and the brakes applied. However, by putting the reversing handle in the neutral position it is possible to avoid maintaining the dead man's handle depressed, though for a driver to do that except under certain carefully prescribed conditions, is of course a serious offence. A variation of this idea is to have a pedal which has to be kept down when running and in some cases a time lag is introduced, enabling the driver to release the knob or pedal for a brief interval without the emergency action being initiated, say in order to move to the other side of the cab and look out. This type of equipment is relatively simple and reliable and gives a fair degree of security. Mishaps sometimes occur with it, however, such as the fatal collision on the Swiss Federal Railways on October 2, 1942, at Tüscherz. A driver of an electric locomotive fell asleep without the dead man's control operating, overran the signals at a crossing place and met an oncoming train head on.

In order to counter this risk as far as possible, apparatus was then provided rendering it not merely sufficient to maintain a knob or pedal depressed in order to keep the emergency braking from coming into action. The driver had now every so often, in acknowledgment of an audible warning, to perform some additional operation, such as pressing a special button or releasing and again depressing the pedal. If this has to be done often enough, however, to obtain the desired degree of security it becomes tiresome and distracting for the driver. A modified arrangement has been devised therefore and applied in Switzerland, as described in this issue, which tests the wakefulness of the driver continuously, practically without his being aware of it. Some movement of either the controller or brake handle is usually made fairly frequently during a journey. This is used as the proving action, so that only when, as seldom occurs, the driver runs more than a predetermined distance without any such action being called for he is warned that he must operate the special acknowledgment button to show he is still alert.

Although this is a development of the dead man's control, and not an automatic train control as ordinarily understood, the equipment can be used in conjunction with any form of the latter. In Switzerland, all distant signals, outer and inner, and all starting signals for entering single-line sections are now fitted with inductive automatic train control, the new dead man's apparatus being an additional security reducing the risks of one-man drive to the practicable minimum. In the form of automatic train control adopted by the British Transport Commission the driver is obliged to acknowledge—thereby cancelling the automatically initiated brake application and producing an indication showing he has done so—every warning received at the approach to an adverse distant or multiple-aspect signal, and this proves not only that he is awake and well but also that he is aware that a fixed signal is against him. This is not, of course, something which can be replaced by a movement of the regulator, controller or brake valve, although that can be regarded as sufficient to check him in connection with the dead man's control. This latter is becoming of increasing interest and importance with the extension of electric working and the replacement of steam by Diesel traction, now so much in evidence.

* * *

DISPATCH FROM GENEVA

Our assistant editor now in Geneva reports hearing many favourable comments on the British exhibition stands at the first International Conference on the Peaceful Uses of Atomic Energy. The stands are lucid in exposition and elegantly arranged. The Russians, at their stands, are very friendly and helpful, showing models of their 5-MW nuclear power station (graphite-moderated and water-cooled), said to be the first in the world. It is housed in a classical-style building not unlike the Tate Gallery in London. But although the Russian exhibition is impressive there is little that is unfamiliar to Western scientists. British firms are well ahead in their readiness to build nuclear power stations to order.

The Americans are the only nation with a reactor for sale—a complete "swimming-pool" reactor erected in the grounds of the Palais des Nations, which has, in fact, already been sold to Switzerland. They have in addition a model of a "boiler" reactor, in which water is heated in the reactor itself, so eliminating the need for heat exchangers; and also a "homogeneous" reactor using the fuel in solution to simplify purification.

Canada claims the most advanced reactor—the 200-MW NRU with power and flux each five times that of their earlier NRX. Britain, too, has announced new reactors, one, the Zeus (Zero Energy Uranium System), which is a fast breeder reactor not designed for power production and already under construction; and the second is a heavy-water reactor to be erected on the Dounreay site. The latter will be similar to Pluto; and Zeus, which should be in operation by the end of this year, will be a full-scale model of the fast-breeder reactor now under construction at Dounreay.

SOME ASPECTS OF THE AMERICAN AIRCRAFT INDUSTRY

IMPRESSIONS OF A VISIT TO CANADA AND U.S.A.

On a visit to North America this summer, we took the opportunity to make a series of lightning visits to some of the major aircraft and engine manufacturers in the United States and in Canada. During these visits—too short and too selective to provide us with a balanced picture of the industry in the Northern American continent—we were nevertheless able to observe some interesting trends and practices, some of which we propose to describe in a future issue. Meanwhile, we present some general observations.

A very large proportion of the American aircraft industry, involving probably more than a quarter of the total manpower engaged in the industry, has become concentrated in California. The reason for this is the dry, equable climate, which simplifies the provision of hangars—much work is carried out in the open—and which makes possible many more test-flying hours per year than can be achieved in uncertain climates like that of Great Britain. The climate and terrain are also powerful factors in attracting personnel to these firms.

In Los Angeles are the headquarters of three of the most important aircraft design and manufacturing concerns in the United States—the Douglas, Lockheed and Northern American companies—and at San Diego is the main branch of Convair, as well as a number of smaller but vital engineering organisations, subcontracting firms and ancillary manufacturers. These cities, we understand, are completely dependent on water supplies piped from the Parker dam on the Colorado river some 500 miles away. In the event of war, a successful enemy or fifth-column attack on these supply lines could presumably put out of action a major part of the aircraft engineering effort of the country. This is clearly a matter of some concern to the U.S. Government and industry; even with the dispersal of manufacturing facilities which is being encouraged, it seems that a high concentration of engineering brain-power is likely to remain in this area.

SECURITY ENFORCEMENT

Security measures are strictly observed in the United States, and representatives of the U.S. Air Force or Navy are stationed at all firms concerned with classified military equipment to ensure that the regulations are enforced. In certain firms it is literally impossible for a foreign visitor to pass beyond the front door unless prior clearance has been obtained from the authorities. Within the organisations themselves, we have been told there is a determined effort to prevent leakages by minimising the number of people "in the know" on highly secret projects—to the extent that, in at any rate one firm (we do not know if this is universal) the mathematical computing section is, supposedly, unaware of the context of the equations they are called on to solve; the parameters are passed to them in coded form so that they cannot identify the symbols, and cannot therefore assess the probable validity of the solutions they produce. It would appear that such practices if carried on to any great extent, could prove a serious embarrassment to rapid design progress.

Turning to some observations on working conditions, we noticed that, particularly in the Californian factories, the workers are encouraged to develop pride in "good housekeeping" i.e., the general tidiness of the area in which they work. Although most of the factories visited have air-conditioned office accommodation, often of the windowless type, this is not universal; and in the shops, although there is usually some forced-ventilation system, full air conditioning is less frequently found. It would, indeed, require a major engineering installation to condition some of these vast plants. On the eastern side of the continent, where the ambient temperatures were above 90 deg. F. at the time of ENGINEERING's visits, the conditions in the shops were far from comfortable, although it has to be remembered that the average American likes to be a little warmer than does the average European.

The American worker has at all times facilities for obtaining soft drinks, cigarettes and even snacks from slot machines conveniently disposed throughout the works. Similar facilities are not available in the two Canadian firms visited, Orenda Engines and Avro Aircraft, Limited, but iced drinking water supplies were provided in all the works seen. We noted that Avro Aircraft, to conserve valuable floor space, have no fixed canteen facilities but provide a serivce of mobile canteens dispensing lunches. In the Californian factories, outdoor dining facilities are provided so that workers can enjoy their midday sandwiches in the pleasant Californian sunshine.

CANADA'S SHORTAGE OF TECHNICAL MANPOWER

Although we hesitate to generalise on conditions in Canada after but two brief visits, it does appear that there is one significant difference between the Canadian and American industries. Whereas technical training schemes at all levels of employment are highly developed in all major American aircraft firms, in the two Canadian organisations—both members of the Avro Canada group, which is itself but 10 years old—such schemes are only now beginning to get under way. Canada's rapidly growing industries are, indeed, at a disadvantage in finding manpower with practical technical knowledge since there are, in Canada, no technical college facilities and apprenticeship schemes as there are in the United Kingdom.

Another difference we noticed—for which we offer no reason—was that whereas no women employees were seen in the shops of the two Avro Canada firms, in America, and particularly on the western side, the proportion of female labour is high, ranging up to 29 per cent. The women work on a wide variety of jobs, and are paid the rate for the job.

Although we did not delve deeply into management problems, we had the impression that in America considerably more emphasis is placed on industrial engineering and work study than is the case in British aircraft firms. It is perhaps natural that the British manufacturer should lag in this field since he rarely has to cater for production in large numbers. Incentives are not generally favoured but, in most American aircraft firms, employers' suggestions for improvements are welcomed and encouraged with substantial financial rewards.

The percentage of engineering staff employed by the American firms is generally high by British standards, and there is a tendency to greater specialisation—perhaps inevitable in organisations generally employing several thousand engineering personnel. (In America, "engineering" is used in its proper sense to denote the more creative aspects of manufacturing activity). The view was expressed by some of the American engineers we met that in some organisations full use is not made of the professionally qualified engineers on the payroll; that too many are employed on operations that could equally well be carried out by lesser qualified staff, freeing the more qualified men for advanced research and development work. We are not prepared to say whether this contention is in fact justified. This, at any rate, is a problem unlikely to arise for some time to come in Great Britain, where the technical manpower shortage makes for greater flexibility in the use of engineering staff, and ensures that any qualified scientist or engineer will be used right up to the limits of his ability; and although he may not be paid so well as his American counterpart, it may be that he has a more interesting and varied life during working hours. But whether or not the Americans are making the best use of their engineers, it is to them that the British aircraft constructor often looks for ideas on new materials, new processes, and new tools.

★ ★ ★

Obituary

LT.-COL. H. S. ROGERS, C.M.G., D.S.O.

Founder Member of Institution of Structural Engineers

It is with regret that we have learnt of the death at the age of 86 of Lt.-Col. H. S. Rogers, C.M.G., D.S.O., who was one of the very few surviving founder members of the Institution of Structural Engineers—originally the Concrete Institute. He had served on the Council during the period 1913-18, and again from 1925 onwards; in 1935 he was appointed a vice-President and in 1938 he was elected to the Presidency. He had in his time served on every committee of the Institution and for the two years prior to becoming President was chairman of the literature committee.

Henry Schofield Rogers was a Canadian born at Peterborough, Ontario, in 1869. He was educated at the Royal Military College, Kingston, Canada; when he graduated in 1889, he won among other prizes that for civil engineering, the Stanley Sword for military subjects and Governor-Generals' Gold Medal for general proficiency. He achieved the distinction of gaining the only commission in the Royal Engineers granted to Canada during that year.

Thereafter followed a period of service both in England and in India with the Corps, and in 1907 he was appointed Surveyor of Prisons in the Home Office, a post he held for the following 28 years. During that time many of the old buildings were modernised with better heating, lighting and ventilation. During this time, also, machine work was adopted in place of hand work in prison industrial shops and many modern workshops with power-driven machinery and other equipment were installed.

On the outbreak of the first World War, Rogers was recalled to the colours and served with the B.E.F. in France from February, 1915, to April, 1919. During that period he earned the following distinctions: C.M.G., D.S.O., Chevalier of the Legion of Honour and four mentions in despatches. Colonel Rogers returned to the Home Office after the war and, after his retirement from the Civil Service in 1935, he set up in private practice as a consulting engineer.

★ ★ ★

MR. ALISTAIR M. GIBB

Civil Engineering in Africa and the Middle East

The death at the age of 54, of Mr. Alistair Gibb, eldest son of Sir Alexander Gibb and senior partner in the firm of Sir Alexander Gibb and Partners, has been widely regretted. Mr. Gibb died on July 29, following an accident at polo—a game that he had done much to revive in England.

Alistair Monteith Gibb was born on April 2, 1901. His father was at that time managing director of the family firm, Easton Gibb & Son, contractors, and was responsible for a succession of contracts culminating with the Rosyth naval base, where he was working up to the outbreak of the first World War. It was in this way that Alistair spent his boyhood in a number of homes in different parts of England and Scotland and during this time saw a variety of large engineering works.

He was educated at Eton and Pembroke College, Cambridge, and then worked as a pupil under the late Sir Basil Mott. Sir Alexander

Gibb & Partners, founded in 1922, were engaged, among other works, in supervising the construction of the Corner Brook paper mills in Newfoundland and there Alistair went to gain further practical experience of large civil-engineering works under construction. Two years later, with the late Mr. Rustat Blake, one of the original partners in the firm, he accompanied Sir Alexander on a business visit to India and Singapore.

After this for some time he followed other interests of his own, joining the Stock Exchange, and farming in Kenya. During the second World War he served with his regiment, the Royal Wiltshire Yeomanry, which he commanded in North Africa and Italy.

He rejoined the firm as a partner at the end of the war and became senior partner in 1948. He brought to the direction of the firm's affairs many of his father's outstanding qualities, plus an outlook that was entirely his own, and a remarkably wide knowledge of the world and of men. His understanding of finance was immensely valuable. He saw very clearly both the opportunities and the pitfalls that lay ahead in the post-war world: the danger of over-specialisation; the almost unlimited and urgent need for development in many countries, necessarily based on civil engineering, and demanding of the engineer a broader approach than had been called for hitherto.

Under his initiative, his firm's connections with East and Central Africa and the Middle East were developed and subsequently established on a firm basis. He was a member of the British Trade Mission to the Middle East in 1945, and under his guidance close connections were maintained with many Middle East countries, and his firm's work in Persia continued uninterrupted by political disturbances from 1946 up to the present time. In Africa he formed a new firm, Sir Alexander Gibb & Partners (Africa), which played a prominent part in the Owen Falls Hydro-Electric Scheme and in other schemes of development in East Africa. In Central Africa the London firm had been appointed, shortly before his death, to undertake, in association with French consultants, the Kariba Gorge Hydro-Electric Project.

While he continued to travel widely and to keep a very close eye on all developments of the firm, he somehow found time for many other activities. His knowledge of Africa was recognised in election to the executive council of the Joint East and Central Africa Board, deputy chairmanship of the Conservative Commonwealth Council, and chairmanship of the East and Central Africa Group. He stood unsuccessfully for Parliament as Conservative candidate for Swindon in 1945, was Honorary Colonel of his regiment and held the Territorial Decoration. He was a prominent member of the Cotswold Hunt and farmed extensively in Gloucester, Scotland and Kenya.

Those who knew him and had worked with him on any of the activities in which he was interested were aware that he was a man with ideas, ideals and great determination. He was ready to listen to the opinions of others and to give sound and helpful guidance; to concede responsibility and, above all, to make big decisions himself whenever it was required of him.

★ ★ ★

We regret also to record the deaths of:

MR. JAMES YOUNG, of Sunderland, in hospital on July 29 at the age of 75. Mr. Young was a former general manager of S. P. Austin and Son, Ltd., Sunderland. He commenced his career as a draughtsman on Clydeside and was general manager of William Gray & Co. Ltd., West Hartlepool, before joining S. P. Austin and Son in the early thirties.

MR. HARRY DENID MELVILLE WRIGHT, in a nursing home at Hove on July 27, at the age of 60. He was a director of the Butterley Co. Ltd., Ripley, and had been associated with them since 1933. Mr. Wright joined the firm as senior London representative, and was appointed to the board of directors in 1945.

MR. GEORGE OLDHAM, in Manchester, on August 1, aged 69 years. Mr. Oldham was a joint managing director of Oldham and Son Ltd., Denton, Manchester.

Letters to the Editor

CONVEYING INFORMATION QUICKLY

Methods and Abstracts

SIR, Mr. H. R. Mills is certain that the same approach is not suitable for the technical man, the departmental manager and the general manager (his letter in your issue of July 29). There is some truth in his contention but, in the limit, every individual's requirements differ from every other individual's requirements and from his own on other occasions.

We should forfeit the advantages of cheap and speedy promulgation, and we should cause confusion, by multiplying indefinitely our forms of presentation of a limited number of facts. Each of us has elements of the manager in his make-up (economics concern everyone, for example) and each member of western civilisation is something of a technician. The "technical man" to-day is to-morrow's manager and then remains in part a technical man.

Is not the ideal to present once what is of common interest to most readers (fundamentals, for example, technical, economic or human) and to branch out with specialist detail from the common source, using the L.C.M.-and-additions or principle-and-exceptions method, rather than to attempt to provide a representative cross-section of all possible permutations of the elements of knowledge?

Yours faithfully,
R. T. CARR.

August 3, 1955.

SIR, In his letter Mr. H. R. Mills did not mention the prefacing of articles by abstracts or brief summaries of their contents. The spreading of this method from scientific to technical periodicals would help not only the engineer but also the librarian and information officer, who in most organisations is expected to cover a vast range of technical subjects. Could ENGINEERING make a start by requesting the authors of major articles to preface their contributions by an abstract ?

Yours faithfully,
JOHN HENNIG,
Librarian.

Electricity Supply Board,
Dublin.
August 2, 1955.

Editor's note: We agree with Dr. Hennig on the usefulness of an abstract at the beginning of a long article; an example occurs in this issue in the article on heat losses of locomotive boilers. No doubt he would agree with us, too, that an article contains more than its abstract necessarily indicates.

★ ★ ★

MAINTENANCE HANDBOOKS

The Information Sheet and the Strip Cartoon

SIR, There has recently been comment in your columns on the efficacy of various methods of presenting technical information. One of the most important and useful vehicles for presenting technical information is the maintenance or user's handbook. In large-scale schemes involving new machines, such as the British Railways modernisation programme, good maintenance will depend to a large extent on the rapid dissemination of standardised and up-to-date maintenance information to all those who need it. In the factory this information can be supplied more easily, and standardised maintenance presents no very serious problems.

The problems of a widely-spread organisation such as British Railways are very similar to those of the Services. During the war the problem of satisfactory maintenance was aggravated because those responsible for maintaining vehicles and plant had often had little previous experience. The results obtained from the use of handbooks were extremely good, and much care was given to their production. They presented the information required in a simple form, but covered all the essentials; above all, maintenance for any particular piece of equipment was standard wherever it went.

In civilian organisations the requirements of the maintenance worker are the same. The handbook which gives him the information he needs should be compact, cheap to produce, so that amendments can easily be incorporated, and should not be too long. If a machine is very involved it should be dealt with in sections, a handbook to each section. The information in each handbook should be strictly relevant to its subject and relevancy should be a fetish with those who prepare the handbooks.

To decide what is relevant the author should have a practical and theoretical knowledge of the equipment in question, and a certain affinity with those who are going to use the handbook. Presentation of the information is a rather special technique, because the handbook must not appear to be a sales brochure or a catalogue, and must appear to the maintenance worker as a practical book for a practical job. It has been found that the typewriter face is the best type face, and has the right appeal to those who use maintenance handbooks.

It is important that information should not be confused with instruction. Experienced workers often resent efforts to instruct them, particularly when those efforts are delivered in a patronising way, but up-to-date information combined with practical skill form an unbeatable combination in any workshop. Two significant developments have taken place recently in presenting technical information of the type referred to above; they are the information sheet and the strip cartoon.

The information sheet is a single sheet, generally headed by an illustration. It has the advantage that it can be replaced without much expense whenever new information must be presented, and saves the trouble of amendment slips. The strip cartoon is more used in America than this country, and has many advantages for quick and vivid presentation. The main difficulty is to find enough artists of sufficient technical knowledge to produce the illustrations.

Pictures are used in many handbooks that do not employ the strip cartoon principle, and they are extremely useful. Often they form more than half the content of a handbook, and it is important to make sure that they are clear. For this reason it is often better to use line drawings rather than half-tones. In sequence pictures the horizontal sequence is far better than the vertical.

I have made no attempt to touch on instructional techniques. They are an important preliminary to information, but in a civilian undertaking it is not always possible to induce men to accept them, especially if they entail travelling away from home. The film, however, as a means of instruction in portable form, is going to revolutionise instructional techniques just as the strip cartoon and the information sheet are going to revolutionise information techniques.

Yours faithfully,
D. K. D. VINE.

London, W.13.
July 22, 1955.

★ ★ ★

SMALL CARS FOR SCIENCE MUSEUM

A new section is to be opened at the Science Museum to depict the progress of British post-war economy cars. A five-year-old Bond Minicar, now undergoing renovation at the Bond works in Preston, Lancaster, has been presented to the museum by Dr. R. S. B. Marsden, of Dumfries, Scotland, and will be on exhibition in a few weeks' time.

NUCLEAR POWER IN CANADA

FORECAST OF DEVELOPMENT AND COSTS

During the International Conference on the Peaceful Uses of Atomic Energy now taking place at Geneva, and in the course of subsequent weeks, we shall be publishing in full, or in abridged or synopsis form, certain of the papers to be delivered there. One of these, by Mr. J. Davis and Mr. W. B. Lewis on the prospective application of nuclear energy in Canada, appears below in a shortened version. Last week in our leading article we referred to the immense capital investment necessary for the development of nuclear power and suggested that it might be some time before returns justified this initial cost; the paper published here indicates some of the factors involved in this problem and assesses them economically. The authors consider their subject with respect to other sources of electrical energy, namely coal, oil, natural gas and water power abundant in Canada, and discuss the effect of nuclear energy in equalising the price of power throughout their country, and in setting a ceiling on its cost. The paper is confined largely to a consideration of the part to be played by medium-to-large (100,000 kW and over) base-load nuclear plants, which are expected to make the principal power contribution.

Although experience of the cost of running nuclear power stations is as yet small, there are enough data to make reasonable estimates of the relative costs of generating electricity by nuclear and conventional means. In a nuclear power station the fuel cost is lower than in thermal power stations, but the capital cost is high. Initially nuclear installations may cost as much as hydro-electric installations, but there is every reason to suppose that capital costs will speedily be reduced. Table I shows the division between variable and fixed charges for various types of power station. The stations are in every case assumed to have a capacity of 100 MW operating at 80 per cent. plant factor. In variable charges are included fuel, labour supervision, maintenance, engineering and miscellaneous supplies. Fixed charges include interest depreciation, insurance, taxes, rentals and dividends.

TABLE I.—*Division of Generating Costs, per cent.*

Station	Coal, oil, or gas-fired steam	Hydro-electric	Nuclear power
Variable charges ..	50	15	10-30
Fixed charges ..	50	85	70-90
	100	100	100

In the earliest types of nuclear power stations it seems probably the natural uranium will be consumed in a "single-pass" system with no recycling. It appears at present that about ½ per cent. of the raw fuel will be consumed and the remainder rejected. In this type of station fuel costs might be up to 25 per cent. of the total cost of electricity, whereas in a station with a breeder reactor, where once-used material is largely re-worked, fuel costs could probably be reduced to 5 per cent. of the total cost. A value between these two has been taken for estimating, namely, that fuel costs are 10 per cent. of the total cost of electricity from a nuclear power station.

Capital charges in building nuclear power plants are likely to remain high, in the region of 200 to 300 dols. per kW of capacity, a figure comparable with hydro-electric schemes. This may be set against the 120 to 180 dols. per kW. of capacity for thermal stations. There can be little doubt, however, that experience will reduce costs, both by suggesting improvements in layout and the use of new materials.

LIFE EXPECTATION OF NUCLEAR POWER PLANTS

The initial capital outlay on plant, equipment, and material inventories is one of our criteria. The rate at which they must be amortised is another. Both have to be taken into account when estimating the fixed charges which nuclear power will have to absorb. Because of a lack of experience, the first nuclear power plants will be assessed as having a relatively short life expectation. In this respect, they will be at a decided disadvantage compared with hydro, which enjoys a background of long-life experience with low maintenance rates. Indeed, until several decades of experience are in hand, depreciation rates are likely to run a per cent. or so above those normally associated with our more conventional types of steam stations. It has to be envisaged that the reactor portions of Canada's nuclear power plants built in the later 1960's and early 1970's will have to be written off in 15 or 20 years. Later, as reactor performance improves, this may be extended to 25 or 30 years, that is to say, to an accounting life similar to that of to-day's coal, oil, and natural gas-fired stations. It is becoming increasingly common in such stations to achieve an increase in efficiency at the expense of increased maintenance replacement of component parts. This is even extending to hydraulic turbines and it may be expected that some such replacement practice will become established also for nuclear power plants. For these reasons it is not expected that a 40 to 50 year life expectation, as is common in the case of water power, would be established.

The necessity to provide for a rapid rate of obsolescence is an initial impediment but it is nothing new. Most revolutionary processes, particularly those of the chemical variety, have for technological reasons suffered a similar handicap at the beginning. Yet because they gave rise to exceptional and sometimes entirely unexpected economies, they were not loo long delayed in arriving on the commercial scene.

One thing that will help more than anything else is for these plants to be run at or near capacity. Shutdowns will be expensive due to the preponderance of fixed charges. To be competitive with other sources of energy, our nuclear power plants will have to be developed to a high degree of reliability. Then, having demonstrated this, and having attained a level of costs somewhat better than the best alternative source of electricity, they can be devoted to meeting the continuous (as opposed to the fluctuating) demands of a particular system. The performance of our nuclear power plants, in other words, will have to be judged in relation to that of the other base-load capabilities which are also available to the power grid or industry in question.

DETAILED COMPARATIVE COSTS

Table II shows detailed comparative costs for various types of power station. In every case the stations are considered to be 200 MW stations operating at 80 per cent. plant factor. Interest has been assumed to be 4 per cent. per annum, and depreciation is calculated on a straight-line basis using 1·5 per cent. for hydro, 2·5 for conventional thermal stations, and 3·5 for atomic-electric stations. The table shows that hydro-electric stations are to be preferred as base-load stations, but it must be remembered that transmission costs will increase the overall cost of electricity, and that suitable sites for hydro-electric stations are often very remote.

TABLE II.—*Estimated Cost in Mills* per Kilowatt-hour*

	Coal, oil or gas-fired station	Hydro-electric station	Atomic-electric station
Production expenses:			
Fuel	1·03–4·17	0·00–0·00	0·50– 1·50
Station labour ..	0·11–0·48	0·04–0·20	0·15– 0·50
Maintenance ..	0·10–0·30	0·03–0·22	0·20– 0·45
Supervision	0·02–0·08	0·01–0·10	0·05– 0·15
Misc. supplies, etc. ..	0·02–0·14	0·02–0·10	0·10– 0·30
Total	1·28–5·17	0·10–0·62	1·00– 2·90
Fixed charges:			
Interest	0·69–1·03	0·86–2·28	1·14–2·86
Depreciation ..	0·43–0·72	0·31–0·84	1·00– 2·50
Taxes, insurance, etc.	0·51–0·78	0·12–0·32	0·86– 2·15
Total	1·63–2·53	1·29–3·44	3·00– 7·51
Total cost ..	2·91–7·70	1·39–4·06	4·00–10·41

* A Mill is one-thousandth of a dollar.

Assessing future developments, the cost of hydro electric stations is likely to remain much the same. Costs will rise, but constructional advances will make savings to restore the balance. For fuel-burning steam stations predictions are not so easy to make, because they depend on the discovery and availability of new sources, and methods of handling present sources. It seems, however, that costs are more likely to go up than to go down. The costs for electricity from atomic power are in the nature of estimates. The figure of 10 mills per kilowatt-hour seems to be a reasonable present-day figure, while that of 4 mills is in the nature of a target. Demands for electricity from atomic-electric stations would begin when the cost was 8 mills per kilowatt-hour, but would not become heavy until the cost had dropped to 6 mills.

COMPONENT COST DATA FOR ATOMIC ENERGY

At this time when no electricity is being generated in Canada from nuclear energy, forecast estimates must be presented and interpreted with reserve. These can be approached most usefully on a component cost basis. First consider production expenses and in particular fuel costs. In 1951 a number of the natural uranium metal fuel rods in the NRX reactor had yielded 3,000 thermal megawatt days per tonne of metal without any reprocessing. Looking to the future, if this yield is obtained in a power reactor, and if the uranium metal can be assembled in the fuel rods at a total cost of 44 dollars per kilogram, then even with the low efficiency of 22 per cent. for conversion of thermal to electrical energy, the fuel cost contribution to the cost of electric power is only 2·78 mills per kilowatt-hour, which is lower than the fuel cost of some large-scale coal-burning generating stations now in operation.

It is hoped that a still lower fuel cost will be achieved and it may be well to review the reasons advanced for entertaining these hopes. It had been feared that the fission products might not be securely contained in the metal at this irradiation level. The stable and long-lived krypton and xenon isotopes which result from fission amount to about 0·22 atoms per fission. In uranium metal at 3,000 MWD per tonne irradiation which is 3 gm. fissioned per kilogram these fission-product gases at normal temperature and pressure would occupy a volume 20 per cent. greater than that of the metal. These gases were nevertheless found securely contained. Containment, however, is likely to fail at higher temperatures. In a power reactor the minimum metal temperature will be higher than in the NRX reactor, but the maximum metal temperature need be no higher than in NRX where it is kept just below 600 deg. C., that is below the α to β phase transition in uranium. Experience since 1951 tends to confirm that the secure containment of the fission products in the metal can be achieved even to higher irradiation, and it does not appear unreasonable to expect containment up to at least 5,000 MWD per tonne irradiation.

Most of our thinking and experience has been concerned with heavy water-moderated reactors with ordinary- or heavy-water cooling. Since uranium reacts chemically with water it is necessary to sheath the metal; aluminium or zirconium are envisaged as the sheathing metal. If a sheath ruptures it is not expected that it would be repaired, and the fuel rod would have to be discharged. Such failures would therefore increase the fuel cost and it is most difficult to assess this liability. We assume it can be kept down to less than 10 per cent. We have sufficient experience of such ruptures developing even in hot water and under irradiation to have confidence that reactor clean-up is practicable and not too costly.

We can assume that with the expected advance of chemical technology the fuel cost with reprocessing will be lower than that attainable otherwise. It may, however, be difficult to achieve costs much below 0·75 mill per kilowatt-hour. Fuel costs are therefore expected to fall with development over the next ten years from about 2 mill per kilowatt-hour to, possibly, 0·75 mill per kilowatt-hour. Correspondingly the fission-energy yield or burn-up from an initial supply of natural uranium will be increased from the 0·4 per cent. (4,000 MWD per tonne) now attainable without reprocessing to about 3 per cent. or even more.

Confining considerations to heavy-water-cooled and moderated reactors dispels difficulties of achieving great enough economy of neutrons to override the poisoning effects of the fission products even for the lengthy irradiations proposed. It does, however, add a significant item of capital investment—the cost of the heavy water. Supposing, however, that the techniques of recovery of heavy water from leaks and spills encountered in reactor operation permit an overall loss rate no greater than experienced with NRX, this capital investment need not be written off rapidly and the annual charges, although significant, appear acceptable. Some relevant cost comparisons with ordinary water are discussed in the paper to this Conference on fuel cycles. If heavy water is available at 66 to 88 dols. per kilogram its use appears economically acceptable.

Though it is the largest, fuel is only one of our variable costs. What about the others? In the early stages of development, it is our expectation that an allowance must be made for labour in the order of one-third greater than that presently encountered in the operation of coal, oil, or gas-fired steam plants. Due to additional precautionary arrangements, repair and maintenance outlays may be higher. Initially, these may be double those associated with today's more conventional thermal plants. Miscellaneous supplies will also cost more. The need to make up for losses—however small they may be in volume terms—of such expensive materials as heavy water, could be a costly proposition. Taken together, these various production charges might work out to as much as 1 mill per kilowatt-hour.

CAPITAL COSTS

From Table II it is seen that fixed charges for nuclear power stations ranged from 3·00 to 7·51 mills per kilowatt-hour, and for coal-, oil- or gas-fired stations from 1·63 to 2·53 mills per kilowatt-hour. A substantial part of the plant of the coal-fired station, namely the turbines and generators, is, for estimating purposes, identical with that in the nuclear plant if the same 80 per cent. plant factor is assumed. This component may range from 60 to 90 dols. per installed kW and therefore contribute from 0·82 to 1·22 mills per kilowatt-hour on the assumptions applied to the coal-fired plant. Subtracting this from the nuclear plant charges leaves the range 2·18 to 6·29 mills per kilowatt-hour for the fixed-charge contribution from the reactor and auxiliaries of the nuclear plant. Converting this back at the 10·5 per cent. rate applied would allow 145 to 420 dols. per installed kW for the reactor and auxiliaries, which for the 200,000 kW station postulated amounts to 29 million to 84 million dols.

As yet we have only an approximate estimate for a 20 MW Nuclear Power Demonstration reactor and auxiliaries which amounts to 7·5 million dols. Scaling this up to 200 MW it is not appropriate to multiply by ten, and it appears that the estimate would lie in the lower part of the allowed 29 to 84 million dols. It has to be below about 45 million dols. for the nuclear power maximum cost to fall below 7 mills per kilowatt-hour.

Totalling up our variable expenses, which might be expected to run around 2 mills, and our larger fixed charges, which might approach 5 mills, gives us a total average cost of nuclear power in the vicinity of 7 mills per kilowatt-hour. Atomic energy plants with an even better performance than this may well be under construction in Canada before 1965.

FORECAST OF DEMAND

The question of future power demands may be assessed in two ways. One method might be termed aggregative in nature and is based essentially on historical data. The other might be called analytical. While it is based on projections of consumption in individual use categories, these projections take account of changes anticipated throughout the world. Totalled up, first by industry and then by area, this alternative procedure should prove to be more descriptive of future developments in established industry.

The results of the first approach are less certain and when extrapolated from a prosperous period are liable to be high. The results of the second, because it is related more closely to known situations, could be unduly conservative. Moreover, taken as the upper and lower limits of a band of possibilities, they take on added significance. Anything within this broadening range of consumption is possible, and it is with this thought in mind that we have attempted to assess what we regard as the likely contribution of nuclear power energy to Canada's future energy requirements.

Using a purely statistical approach, past trends can be projected well into the future. In this fashion, we arrive at an average annual rate of growth in the total demand for electric power in Canada of around 6 per cent. per annum. Doubling every 12 years, consumption could be expected to increase more than four-fold over the next quarter century.

Using the more detailed industry by industry and area by area approach, we arrive at an overall rate of growth which tends to become more modest over the next three decades. Little more than a threefold multiplication in the nation's requirements for electric power is expected to occur between now and 1980. The following table illustrates the annual rate of growth forecast in five-year intervals for the next 25 years, using this preferred method of estimating Canada's future power needs:—

TABLE III.—*Demand for Electricity, Percentage Annual Rate o Growth*

Period	1956–60	1961–65	1966–70	1971–75	1976–80
Per cent. ..	5·5	5·0	4·6	4·3	4·0

It seems important to recognise the changing pattern of the nation's industrial development, because in Canada to-day two or three industries account for over half of the total consumption of electric power. A market analysis for these industries has therefore special significance. Moreover they are subject to a general trend towards chemical methods for processing raw and semi-manufactured materials. This is true, not only of the refining of non-ferrous metals, but also of the manufacture of pulp and industrial chemicals.

Finally, we may face the prospect that really cheap nuclear power, should it become available in 20 or 30 years' time, will favour the location of certain heavy power-using industries, like the refining of the light metals, close to the principal industrial markets of the world. Were this to happen, a large segment of Canada's established demand for new increments of power would disappear. This could more than offset the use of electricity in the electrolytic refining of such "new" metals as titanium and in the treatment either by electro-metallurgical or electro-chemical means of other natural resources indigenous to this country. This affects the harnessing of a special type of very low cost power, namely large hydro-electric potential at some distance from the other centres of power demand. At the same time it has to be noted that the population of Canada, as another component of the demand, seems likely to be forced to continue to increase its productivity and to use in whatever work it prefers to do an increasing amount of power.

It is with all these considerations in mind that we have, therefore, come to the conclusion that the annual percentage rate of growth in consumption may well decline. Perhaps it will fall from the present rate of close to 6 per cent. to around 4½ per cent. in the 1970's. Total power requirements, nevertheless, will continue to mount. Annual installations varying between 1 million and 2 million kW will, therefore, still be required throughout the 1960's and 1970's.

ELECTRICITY SUPPLY

Having assessed, in a very general way, the aggregate demands which are likely to be encountered in this country, let us turn once more to the question of supply. Our regional cost studies indicate that hydro-electric power will remain the nation's principal source of electrical energy. Even in 1980, it may add up to as much as two-thirds of the installed capacity in this country. Meanwhile, thermal generation will have become much more important. It will rise from what were negligible proportions a few years ago to at least 30 per cent. of Canada's total installed capacity 25 years from now. Table IV shows a possible division between various types of electricity generating stations.

TABLE IV.—*Forecast of Division of Installed Capacity (Million kW).*

Date	Total	Hydro	Other		
			Total	Coal, oil, gas	Nuclear
1951 ..	11·1	10·0	1·1	1·1	Nil
1956 ..	16·0	14·0	2·0	2·0	Nil
1961 ..	22·5	20·0	2·5	2·4–2·3	0·1–0·2
1966 ..	28·0	24·5	3·9	3·7–2·9	0·2–1·0
1971 ..	34·0	27·4	6·6	6·0–4·9	0·6–1·7
1976 ..	41·0	30·2	10·8	8·8–7·5	2·0–3·3
1981 ..	48·0	33·0	15·0	11·0–8·0	4·0–7·0

These figures indicate that the part played by nuclear energy, while modest in the years immediately ahead, is expected to expand rapidly. Our calculations, based on the cost expectations outlined previously, point to the possibility that several millions of kilowatts of capacity will be installed during the early 1970's. By 1980, nuclear power plants may conceivably account for as much as 10 to 15 per cent. of the total generating capacity in this country.

This forecast of the demand for nuclear power—if it is realised—will have important repercussions on many sectors of the Canadian economy. Are they of manageable proportions? Looking at the major material and plant and equipment requirements likely to stem from this prospective revolution in the thermal power field, numerous opportunities and challenges appear to be in the offing.

As to the nuclear-fuel requirements of such a programme, there is little cause for alarm. Even assuming that the "burn up" of natural fuel is limited to 3 per cent., Canada's total needs, up to and including 1980, will amount to no more than several thousand tons. Obviously the domestic mining industry will have to look elsewhere for a market for much of its production of new metal.

The situation with regard to heavy water is something else again. Here, the necessary tonnages may be many times that of the nation's present production capacity. What could, in time, become a sizable segment of Canada's chemical industry may, therefore, have to be created in order to cater for this large and rapidly expanding demand for this material.

Phased in five-year intervals, the probable cumulative material needs of a recycled natural uranium system are shown in Table V.

TABLE V.—*Recycled Natural Uranium System Capacity and Material Requirement*

Year	Installed capacity (mkW)	Inventory natural U (tonnes)	Annual make-up Natural U (tonnes)	Inventory heavy water (short tons)
1961 ..	0·1–0·2	60– 120	4– 8	100– 200
1966 ..	0·2–1·0	120– 600	8– 40	200–1,000
1971 ..	0·6–1·7	360–1,020	24– 68	600–1,700
1976 ..	2·0–3·3	1,200–1,980	80–132	2,000–3,300
1981 ..	4·0–7·0	2,400–4,200	160–280	4,000–7,000

PERSONAL

MR. NORMAN MCCALLUM, T.D., M.A., A.M.I.Mech.E., M.I.Mar.E., has been elected chairman of the Council of the British Internal Combustion Engine Manufacturers' Association, 6 Grafton-street, London, W.1, in succession to MR. W. K. G. ALLEN, who has been chairman of Council since June, 1953. MR. MILES BEEVOR has been elected vice-chairman of the Council.

The Engineer's Guild have elected MR. BRYAN DONKIN to continue as President for a further year from December next. The Chairman of Council for 1956 will be MR. E. W. GREENSMITH, and MR. G. E. M. GODFREY will be vice-president. MR. J. H. W. TURNER having expressed the wish to be relieved of the position of honorary secretary, in December, 1956, it has been agreed that the assistant secretary, MR. J. G. ORR, shall be appointed secretary of the Guild, as from the date of the annual general meeting in December, 1955. A successor to Mr. Turner will not be appointed.

MR. E. BRUCE BALL, C.B.E., formerly managing director of Glenfield and Kennedy Ltd., has been elected an additional director of Metal Industries Ltd., Universal House, 60 Buckingham Palace-road, London, S.W.1.

MR. H. H. MULLENS, B.Sc., M.I.E.E., has been appointed a non-executive director of Dorman, Long & Co., Ltd., Zetland-road, Middlesbrough.

The Ministry of Supply announce that DR. E. A. PERREN has been appointed chief superintendent, Chemical Defence Experimental Establishment, Porton, Salisbury, Wiltshire, with effect from September 1, 1955, in succession to MR. S. A. MUMFORD.

MR. H. D. ADAM, A.M.I.Mech.E., M.I.Mar.E., M.Inst.Pet., has been joined in his Diesel engine consulting practice by LIEUTENANT A. L. GIORDAN, M.B.E., D.S.C., M.I.Mar.E., who has recently retired from the Royal Navy. The style of the firm is now ADAM AND GIORDAN, 5 Whittington-avenue, London, E.C.3. (Telephone: MANsion House 4471.)

SIR THOMAS SHEEPSHANKS, K.C.B., K.B.E., permanent secretary of the Ministry of Housing and Local Government, Whitehall, London, S.W.1, is retiring from the public service on October 1. He will be succeeded by DAME EVELYN SHARP, D.B.E., at present deputy secretary of the Ministry.

MR. JOHN PAISLEY, M.I.Mech.E., M.I.Prod.E., F.I.Ceram., and SIR GILBERT DAVIS, Bt., A.M.I.Chem.E., have been appointed assistant managing directors of Eastwoods Ltd. Both are present members of the parent board.

MR. RONALD NEWELL, M.I.Mech.E., M.I.Mar.E., engineering manager, Harland & Wolff Ltd., Belfast, has been elected to the board of the company. MR. F. V. SPARK, C.B.E., director, chief accountant and secretary, has retired after 45 years of service with the company. MR. G. H. PATTON has been appointed secretary and MR. W. T. UNDERWOOD, M.A., chief accountant.

MR. A. G. ELLIOTT, formerly production controller of Sheepbridge Equipment Ltd., has been appointed works engineer of the Chesterfield Works of the Sheepbridge Engineering Group. MR. A. WELLS has succeeded Mr. Elliott as production controller, Sheepbridge Equipment Ltd. MR. G. A. MEIKLE has been appointed apprentice training officer at the Chesterfield works. MR. E. DENNIS has been appointed sales manager of Automotive Engineering Ltd., Twickenham, and Light Production Ltd., Slough. MR. E. A. MACDONELL has been appointed sales manager of Clews Petersen Ltd., West Hampstead.

DR. NICOL GROSS, M.I.Mech.E., M.I.W., at present reader in production engineering, Imperial College of Science and Technology, London, has been made deputy managing director, Quasi-Arc Co. Ltd., Bilston.

MR. A. J. HARRIS, B.Sc.(Eng.), A.M.I.C.E., of 128 Ashley-gardens, London, S.W.1, has relinquished his appointment as director of the Pre-Stressed Concrete Co. Ltd., and is now in private practice.

W. T. Henley's Telegraph Works Co. Ltd. announce that MR. E. J. VIDLER, who has been general manager since January 1, 1954, now becomes director and general manager, and MR. S. J. BEANEY, secretary of the company since April 1, 1954, becomes director and secretary.

MR. D. E. LAMBERT, B.Sc.(Eng.), M.I.E.E., has been appointed manager of the switchgear division of the Brush Electrical Engineering Co. Ltd., Loughborough, from October 1.

CAPTAIN PETER WRIGHT has been appointed commodore commander of the fleet of the British India Steam Navigation Co. Ltd., 122 Leadenhall-street, London, E.C.3, in succession to CAPTAIN G. A. PATERSON, who is retiring.

The board of Horseley Bridge and Thomas Piggott Ltd., Horseley Works, Tipton, Staffordshire, announce that MR. B. VINCENT SMITH, a director of their subsidiary companies, has now been appointed an official director of the parent company.

Johnson and Phillips, Ltd., Charlton, London, S.E.7, announce that MR. H. J. OLLEY has been made cable-works manager, responsible for both the rubber-cable and paper-cable works. He will be assisted by MR. B. C. BROWN who becomes assistant manager of the rubber cable works and MR. W. MANN who becomes assistant manager of the paper cable works. MR. F. J. C. HOLLIMAN has been appointed manager of the employment and welfare department and MR. E. A. TWINE, manager of the cable cost department. MR. C. E. COLLAR, A.M.I.E.E., has been made assistant manager of the transformer department and MR. H. WEST, assistant manager of the cable estimating department.

MR. R. H. HAINSWORTH, managing director of Specialloid Ltd., and Aero Piston Ring Co. Ltd., has been released from these appointments to become managing director of J. and H. McLaren Ltd., Leeds. He will take up his duties on November 1, on which date MR. T. O. HUNT, at present technical and works director, will assume the managing directorship of Specialloid Ltd., and Aero Piston Ring Co.

DR. ARNO C. FIELDNER, of Washington, District of Columbia, U.S.A., the well-known authority on coal and related fuels, has retired from the United States Bureau of Mines after more than 48 years of Government service. He was awarded the Melchett Medal of the Institute of Fuel in 1942.

MR. E. V. NORCOCK, hitherto secretary of the aircraft division of the Bristol Aeroplane Co. Ltd., has joined the board of Export Packing Service Ltd., Imperial Buildings, 56 Kingsway, London, W.C.2.

MR. W. H. M. JACKSON, O.B.E., industrial relations officer to the Cable Makers Association, High Holborn House, 52-54 High Holborn, London, W.C.1, for the past 13 years, has retired. He is succeeded by MR. T. H. PIKE.

MR. J. D. C. CHURCHILL, at present planning officer to London Transport Executive, 55 Broadway, London, S.W.1, has been appointed assistant secretary. The title of planning officer is to be discontinued.

★ ★ ★

COMMERCIAL

After an interval of 15 years, the registered office of the MOND NICKEL CO. LTD. is once again Thames House, Millbank, London, S.W.1.

THE SKEFKO BALL BEARING CO. LTD., Luton, Bedfordshire, have opened a new branch office at Waterloo Buildings, London-road, Southampton. (Telephone: Southampton 27313/4.) The manager is MR. L. E. WILLSON, until recently in charge of the firm's Cardiff office.

From August 22, the address of THE COUNCIL OF INDUSTRIAL DESIGN will be 28 Haymarket, London, S.W.1. (Telephone: TRAfalgar 8000.)

The merchandising division of the SOLARTRON ELECTRONIC GROUP, LTD., Thames Ditton, Surrey (the new telephone number of which is EMBerbrook 5522), is now the appointed agent for the CONSOLIDATED ENGINEERING CORPORATION, Pasadena, California, U.S.A., and associated companies, for the United Kingdom, Eire, and certain parts of the British Commonwealth.

SENTINEL (SHREWSBURY) LTD. announce that A. H. EDMONDS & SON PTY. LTD., 217 Beardy-street, Armidale, New South Wales, Australia, have been appointed official distributors of the Sentinel Diesel road vehicles thoughout the State of New South Wales.

SULZER BROS. (LONDON) LTD., 31 Bedford-square, London, W.C.1, and the COMMONWEALTH ENGINEERING CO. LTD., 11 Berry-street, Granville, New South Wales, Australia, have completed negotiations for the building of Diesel locomotives in Australia. The locomotives will be marketed under the name "Comeng-Sulzer."

THE UNITED STRIP AND BAR MILLS, a wholly-owned associate of STEEL, PEECH AND TOZER, and the manufacturing and trading activities of which have been amalgamated with Steel, Peech and Tozer for many years, as from August 8, have ceased to trade under a separate name and title. Their activities and trading will be carried on, in future, in the name of Steel, Peech and Tozer, a branch of the United Steel Companies Ltd., Sheffield.

CONTRACTS

Atomic Power Stations. The contract for the second Calder Hall atomic power station, announced in Parliament on June 13, has been placed with TAYLOR WOODROW CONSTRUCTION LTD., Ruislip-road, Southall, Middlesex, the building and civil-engineering contractors for the first Calder Hall power station. The new building, to be known as Calder Hall "B," will be alongside and identical with the original Calder Hall station which, next year, is due to generate electricity in marketable quantities. The contract, placed by the United Kingdom Atomic Energy Authority, is valued at over £2 million and will take 2½ years to complete. The work will include the construction of the foundations, two 120-ft. high reactor buildings with a turbine hall and a two-storey administration block between, two 300-ft. high cooling towers, and ancillary works including roads, drainage, fencing and ducts. Messrs. Taylor Woodrow have also begun to work on another atomic contract for the Authority. This, valued at £250,000, is for the preliminary site works at Chapelcross power station, Annan, Dumfrieshire. The consulting engineers are MESSRS. MERZ AND MCLELLAN.

Rolling Mill. An order valued at £550,000 to build a new 18-in. Morgan continuous skelp and strip rolling mill for the steelworks at Newcastle, New South Wales, of the Broken Hill Proprietary Co. Ltd., has been placed with the DAVY AND UNITED ENGINEERING CO. LTD., Park Iron Works, Sheffield, 4. This mill will be engaged primarily on the quantity production of high-quality steel strip for subsequent processing into tubes. It will consist of 14 stands and will be supplied with a considerable quantity of auxiliary handling and control equipment. Delivery is expected to be made early in 1957. A mill of this size and type, it is stated, can produce in excess of 500,000 tons of strip a year.

Telecommunications Equipment. Approximately a year ago, the Canadian Marconi Co. placed an order for several hundred thousand dollars' worth of communications transmitters and receivers with MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex. This contract, originating from the Canadian Overseas Telecommunications Corporation, provided the main materials for new long-distance transmitting and receiving stations to be built at Vancouver and for the expansion of the Montreal station. Another substantial order has now been received by the English firm from the same source. This calls for more equipment for the same projects. The new contract provides for the supply of six Marconi-Siemens radio telephone terminal equipments, type HW21, together with inverters, channel displacing and restoring equipment and several channel bays of five-band privacy equipment.

Catalytic Oil Gas Installation. The North Thames Gas Board has placed an order with the POWER-GAS CORPORATION LTD., Stockton-on-Tees, for a Segas catalytic oil-gas installation at their Uxbridge works. The plant will consist of two Segas units, each producing 1,500,000 cub. ft. of gas a day and will be complete with all the necessary ancillary equipment. A single waste-heat boiler will serve both units, and a separate oil-fired boiler will be provided to supply the balance of the steam requirements. A low-pressure steam system incorporating a steam accumulator will take the exhaust steam from the exhauster and air blower to provide process steam to the plant.

The project includes foundations, building, oil-storage tanks, relief gasholder, electrostatic detarrer and napthalene washer. Provision is made for the re-circulation of cooling liquor over a cooling tower from the direct-contact washer cooler. It is expected that the plant will be in operation by the end of 1956.

Aerial Surveys in British Guiana. As part of the Government's policy to aid Colonial development, the Directorate of Colonial Surveys is undertaking a further aerial survey of British Guiana, the contract for which has been awarded to HUNTING AEROSURVEYS LTD., Norwich House, Dunraven-street, Park-lane, London, W.1. This is the fourth aerial survey contract in British Guiana since the war. The 54,000 square miles of British Guiana yet to be surveyed include some wild and largely unexplored country. Aerial survey work is difficult as even in the best season (August to November) low cloud over the thick jungle often makes photography impossible. The aircraft to be used will be a Lockheed Hudson from Kenting Aviation Ltd., specially equipped for photographic service.

Book Reviews

NOT A "TRAINED" ENGINEER

The Life of Lord Nuffield: A Study in Enterprise and Benevolence. By P. W. S. ANDREWS and ELIZABETH BRUNNER. *Basil Blackwell, 49 Broad-street, Oxford.* (25*s.*)

Businessmen are more difficult subjects of biography than statesmen, artists or men of letters, because they are generally inarticulate, and have little sense of their own importance. Their lives tend to be more single-minded and their work can only be seen in the hard terms of industrial buildings, plant and stocks as recorded in balance sheets. They rarely keep diaries and, however gigantic the organisations that they have created, few of the decisions by which they were built, or the reasons for taking them, are formally recorded. It is extraordinary, for instance, that the authors of this book have to report in a footnote that Lord Nuffield's personal files were destroyed during the war as part of the salvage campaign.

For these reasons and because so many of those concerned, including the subject himself, are still alive, this story of an undoubted genius never comes to life. It fails to convey to the reader either a full, rounded picture of Lord Nuffield as an individual, either in public or private life, or the vast spread of enterprises which became the Nuffield Organisation as a living and growing organism. Nevertheless, as an outline for a future study of both the man and the business, there is a great deal of interest in it.

William Morris was not a trained engineer, although he was certainly born an ingenious mechanic. In the early days it was his "clinical" experience in the repair of different makes of motor car that enabled him to start his own manufacture with a design that was immediately successful. The chief tangible reason for his success in a rapidly growing, but highly competitive, new industry was his realisation of the cost advantages of large-scale production and of manufacturing specialisation. Unlike most of his competitors, Morris manufactured little of the car which he began to assemble at Cowley fifty years ago (the engines for the Morris Cowley in 1915 were, in fact, made in America) but his experiences in munitions production during the first World War strengthened his views and laid the basis of the policy on which Morris Motors expanded so rapidly in the early twenties. Only in later years did the need to ensure supplies and the unwillingness of suppliers to tie too great a proportion of their output to one buyer lead to the acquisition of the firms making engines, bodies and other components and their eventual integration into the organisation. The authors may have underestimated the importance of that war-time experience in Morris's development as a production organiser and the profits made during that period in providing the finance for the subsequent expansion; although the war came during a year in which sales and profits had trebled and interrupted a rapid expansion of the business.

Lord Nuffield's genius appears in his sense of the economics of production and his instinctive understanding of the dynamic effect on reducing costs of high and continuous output; whether he had imbibed any theoretical economics from his academic neighbours or not, he understood the meaning of "marginal" cost and price. It was this understanding that enabled him to take the dramatic decision to make drastic reductions in price in the middle of the slump in 1921, which would seem to be certain to put his company into bankruptcy; but even he was surprised at the effect on his sales, which went up five times in as many months. What was good for his business applied equally to his suppliers, and he drove hard bargains with them based on what he knew would be the reduction in their costs from the increased sales. As a result of these methods the Morris share of the industry's annual output, which had itself gone up in the five years after 1920 from 44,000 to 150,000, rose from under 5 per cent. to 41 per cent. and many names, now famous, were established among the manufacturers of components. It comes as something of a shock to realise that, in spite of the great increase in production, the conveyor was not introduced to the Cowley assembly line until 1934.

The motor industry has always been to some extent a fashion industry, and before the last war its production programme was made unduly seasonal by the habit of announcing changes at the time of the Motor Show. Lord Nuffield broke with this tradition in 1938, by the introduction of his "series" production. During the difficult early 1930's he may have suffered from producing too many types; in 1933, there were 8, 10, 12, 14, 16, 18 and 25 h.p. models. The Morris Cowley was still basically the same car that had been first manufactured in 1915 and there may have been delay in developing a new popular car. In fact, one of the criticisms that have been made of Lord Nuffield is that he was not sufficiently interested in research and development and at this period there was inadequate technical leadership at the top of his companies. This is, of course, one of the symptoms of rapid growth from simple one-man business to modern managerial company, and one would have liked to have heard much more about the problems of management and of human relationships between Lord Nuffield and his staff, particularly about "the Organisation," as the group of managers and foremen who advised him were known in the 'twenties and from which grew the Board of Directors of Morris Motors Limited, in 1926, and also about those leading to the major reorganisations of 1933, 1936, 1947 and, prior to the merger with Austin, in 1952.

This book describes the enormous benefactions by which Lord Nuffield has disposed of the great wealth which he built up. In 1954, the market value of the shares in the British Motor Corporation, which are held in perpetual trust on behalf of some of them, amounted to more than £20 million. He acquired this money not because he wanted it, but as the inevitable result of carrying out his purpose in building motor cars on a large scale, which he was able to do by virtue of his faith in his own judgment, and his maintenance of his independence to make his own decisions, involving great risks, to back that judgment. Only when, as a result of two super-tax cases, he felt that the financial growth of the business might be injured by his personal ownership of it, and because his outside activities were growing, did he put the ordinary shares on the market and so start the process of divesting himself of control.

The question that every reader will ask himself as he puts this book down is whether it can ever be done again; whether one man can ever, with present-day taxation, build such a business without outside finance on a greater scale than Lord Nuffield ever had it, and whether any new industry is likely to arise which can be developed almost entirely on the basis of practical, and not scientific, knowledge.

Mastering Momentum. A Discussion of Modern Transport Trends and Their Influence upon the Equipment of American Railways. By LEWIS K. SILLCOX. Second edition. *Simmon-Boardman Publishing Corporation, 30 Church-street, New York 7, N.Y., U.S.A.* (No price quoted).

This book is concerned primarily with the theory and American practice of braking railway trains, and secondarily with the effects of braking on wheels, axles, bogie trucks, rails and draw-gear, all of which have been modified in design to meet the increasingly severe service conditions imposed by high-speed trains. The author, now honorary vice-chairman of the New York Air Brake Company, is unexpectedly reticent as regards the detailed construction and functioning of brake equipment, preferring to survey in a general way the mechanics of train operation and braking, and to supplement his analyses of brake performance by data from tests made over 20 years ago. The revised text is, in fact, largely identical with that of the first edition, published in 1941, and railway engineers who are familiar with that book will be disappointed that the additional matter in this revision is woefully incommensurate with the drastic change from steam to Diesel-electric motive power that has taken place in America during the past 15 years. Admittedly, there is some discussion of the differences in performance characteristics between steam and Diesel trains, and some revised thoughts on brake shoes of non-ferrous materials, which are topical in this country in view of the present motive-power policy. On the whole, however, this is a book for young railway mechanical engineers rather than for experienced men facing new braking problems.

* * *

INSTITUTION OF PUBLIC HEALTH ENGINEERS

As was briefly noted on page 183 of last week's issue, the name of the Institution of Sanitary Engineers has now been changed to the Institution of Public Health Engineers. The change formally took effect on July 7, nearly 60 years to the day since the original Institute of Sanitary Engineers was founded, and characterises the developments in engineering appertaining to public health.

In 1895 the Institute of Sanitary Engineers was inaugurated. There was an earlier organisation of which the Institute was the successor but enemy action in two world wars and various changes of address in those early days have left only a few records and these do not include even its name. By 1915, the members felt that the status and influence of the Institute had grown to such an extent that an amendment of the title to that of Institution was warranted. Accordingly, a memorandum of association was drafted and in due course signed on March 9, 1916 by 25 persons who, it would seem very probable, were members of the council of management at that time. The old Institute was wound up and, on May 23, 1916, a certificate of incorporation was issued to the Institution of Sanitary Engineers (the word Limited being omitted by licence of the Board of Trade). Thus the Institution became (technically) a registered company as a further step in its growth.

Early in 1953 the Council accepted the fact that members felt that the name of the Institution was no longer associated in the public mind with their activities, and in June of that year action required to effect the change of name was initiated. The change has also given the Council the opportunity to make modifications to the articles and by-laws.

It is of interest to quote how this Institution defines the profession, viz.:—"The art and science of designing, supervising, executing and administering works intended to assist, develop and control the forces of nature in order to maintain and improve the health of the community." And its definition of a public health engineer is "a person who is engaged as an engineer in connection with public health and who designs, or controls, or undertakes, or advises upon constructional works or other like matters affecting the health of the community."

The words "formerly the Institution of Sanitary Engineers" will be used after the new name, and provision has been made so that present members who prefer to use the appropriate abbreviated designation F.I.San.E., M.I.San.E., A.M.I.San.E., Hon.F.I.San.E., A.I.San.E., or Stud.I.San.E., may continue to do so instead of using the new abbreviations F.I.P.H.E., M.I.P.H.E., A.M.I.P.H.E., Hon. F.I.P.H.E., A.I.P.H.E., or Stud.I.P.H.E.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Tractor Equipment. MASSEY-HARRIS-FERGUSON (SALES) LTD., Coventry. Multi-purpose blade for grading, ditching, backfilling, etc.; 6 ft. normal cutting width; blade angle, 0 to 60 deg. forward or reverse; pitch 0 to 40 deg. Transporter with capacity of 1 cubic yard. Parking brake latch accessory to secure master brake pedal in "on" position. Combined speed reduction and live p.t.o. unit described in ENGINEERING for July 15, 1955 (vol. 180, page 92). All the above items are designed for the Ferguson tractor. Four illustrated leaflets.

Pressed Steel Tanks. BRAITHWAITE AND CO. STRUCTURAL LTD., "The Moorings," Church-road, Great Bookham, Surrey. Tanks built from pressed steel plates: ranging in size from small elevated storage tanks to reservoirs for communities; purposes include storage of water, oil and other fluids, constructional in-filling for caissons, etc. Specifications. Covers and supports; pipe connections and fittings; other company information. Loose leaf illustrated booklet.

Agricultural Machinery. E. H. BENTALL & CO., LTD., Heybridge Works, Maldon, Essex. A history of the firm of E. H. Bentall commemorating 150 years' service to agriculture, describing the equipment produced and the personalities of the Bentall family. An illustrated book entitled "The Bentall Story," by Lt.-Cmdr. P. K. Kemp, F.R.Hist.S., R.N.

Glass-Reinforced Plastics. FIBREGLASS LTD., Ravenhead, St. Helens, Lancashire. Description of different types of reinforcement, moulding and casting techniques, miscellaneous properties of glass-reinforced plastics, examples of articles made from the material. Booklet with illustrations and explanatory diagrams.

Screw Pitch Measuring Machine. COVENTRY GAUGE AND TOOL CO., LTD., Coventry. Machine for determining the pitch of parallel screw threads; reveals inaccuracies of less than 0·0001 in. over 2 in., repeats readings to within 0·00002 in.; maximum external thread admitted 4 in., maximum length between centres 18 in. Illustrated leaflet.

Road Forms. BLAW KNOX LTD., 94 Brompton-road, London, S.W.3. Steel road forms and screeds. Types suitable for heavy and light slabs. Heavy-duty type with independent rail attachment for travelling vibrating machinery and surface finishers. Also flexible forms for making tight radii at road corners, etc. Publication No. BK-216.

Feed-Water Controller. JAMES GORDON & CO., LTD., Dalston-gardens, Stanmore, Middlesex. "Hagan" three-element feed water control system. Pneumatically operated relays governed by water level, set level, and summated signal. Catalogue H 54.

Arc-Welding. QUASI-ARC CO., LTD., Bilston, Staffordshire. "Economics of Arc Welding," brochure compiled to give advice on methods and materials, including estimating and cost charts for labour and materials.

Materials Handling. HYSTER CO., Box 4318, Portland 8, Oregon, U.S.A. Field reports on the use of lift trucks and other equipment for handling bales, logs and other contractors' materials. Illustrated leaflets.

★ ★ ★

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Laminated Beams from Two Species of Timber: Theory of Design. By W. T. CURRY. Forest Products Research Special Report No. 10. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

Laminated timber construction enables large members to be made from relatively large stock, permits a uniformly dry condition to be obtained through large sections and makes possible the tapering of structural members to conform with the stress patterns likely to be encountered in service. Moreover, by gluing comparatively thin laminations of a dense strong wood to a core of weaker wood, the economical advantages of the technique can be exploited even further. Report No. 10 examines the design methods available for analysing laminated wooden members and compares the results of calculations with figures obtained in a laboratory investigation.

Filling and Sealing Materials for Joints in Concrete Roads. By R. S. MILLARD. Road Note No. 7. Second edition. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

This note describes the various types of joint which are now in use for road construction and the different methods available for sealing the joints against the ingress of water, which would soften the subgrade, and of grit, which would cause spalling of the slab if trapped in the joint. The properties required by the filling and sealing compounds are specified and brief descriptions given of the types of materials now available. Descriptions of the machinery required for the work of making and maintaining joints have been added in this second edition of the note.

Wind Effects on Bridges and Other Flexible Structures. N.P.L. Notes on Applied Science No. 11. *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

In recent years the N.P.L. has carried out investigations on the oscillatory effects of wind on two proposed suspension bridges—the Severn Bridge at Beachley, and the Runcorn-Widnes Bridge over the River Mersey. The new booklet describes these two investigations, but much of the contents applies in principle to other flexible structures such as tall chimneys, transmission-line pylons and buildings generally. The experimental methods used are discussed in detail, illustrations being given of the equipment and of models undergoing tests in wind tunnels.

Analysis of Symmetric Cylindrical Shells: Its Application to Civil Engineering Design. By JOHN MCNAMEE. Published for Building Research Station, Department of Scientific and Industrial Research, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (12*s.* 6*d.*)

Dr. McNamee's book is arranged in the form of a course of lectures intended for those approaching the theory of thin cylindrical shells for the first time. Although limited to an account of the elements of the theory, analysis is carried to the point where it can be used to determine numerical values for stresses in shell roofs. The author assumes a familiarity on the part of his readers with the concepts of beam and slab analysis and, for a full understanding of the booklet, engineers require a working knowledge of Fourier series and matrix algebra.

Timbers of South East Asia. By GERALD HART. *Timber Development Association, Limited, 21 College-hill, London, E.C.4.* (Free on application.)

Descriptions of about 40 timbers of interest to British markets are contained in this new publication of the T.D.A. The notes, covering the uses, properties and working qualities of the timbers, are arranged in alphabetical order of their standard names in accordance with the British Standard: "Nomenclature of Commercial Timbers." The references to kiln schedules follow those suggested by the Forest Products Research Laboratory.

Calibration of Temperature Measuring Instruments. N.P.L. Notes on Applied Science No. 12. *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.*)

This series of "Notes on Applied Science" is published by the National Physical Laboratory with the object of providing industrialists and technicians with information on various scientific and technical subjects not readily available elsewhere. Booklet No. 12 is concerned with the basic scales of temperature and the instrumental means by which they are realised, and describes the methods of calibration currently employed at the Laboratory, Teddington.

Investment Precision Casting. "Machinery's" Yellow Book Series No. 35. *The Machinery Publishing Company, Limited, National House, West-street, Brighton,* 1. (4*s.*)

This little volume presents a collation of material which has already appeared in the periodical *Machinery*, together with various additions. Descriptions are given of wax patterns, wax injection machines and furnace types, and data are furnished regarding the production of wax patterns, the dewaxing and firing of the mould, the pouring of the metal and other matters. The book is intended for students as well as intending practitioners in the process.

Irrigation in India Through Ages. Second edition. Leaflet No. 7. *The Secretary, Central Board of Irrigation and Power, Curzon-road, Barracks, New Delhi, India.* (10*d.*)

Irrigation has been practised in India since time immemorial. This pamphlet, the work of the Department of Archaeology, is an attempt to trace the references in the ancient literature of India to the existence of dams, canals and irrigation works generally, and of the methods adopted by earlier civilisations for the distribution of water. The greater number of references are to the 1,000-year period prior to the middle of the Seventeenth Century.

Bestimmungen des deutschen Ausschusses für Stahlbeton. Sixth edition. *Wilhelm Ernst und Sohn, Hohenzollerndamm* 169, *Berlin-Wilmersdorf.* (12·50 D.M.)

The first edition of "Specifications of the German Committee for Reinforced Concrete" appeared in 1946 and the present sixth issue consolidates the position as at April, 1955, embodying separate supplements to the fifth edition. The work constitutes a collection of German standard reinforced-concrete specifications applicable for drawing up projects and for the use of fully qualified contractors. Provisional guiding principles issued at the time the present book was going to Press, and supplementing existing standards for concrete and reinforced-concrete walls for superstructures, have been included as an appendix at the end. The contents are indexed according to the serial number of standard specifications and alphabetically by subject matter. A further list of contents shows the order of treatment of the subject under the main headings: (1) Calculations and methods—covering reinforced-concrete and pre-cast members; prestressed concrete; reinforced ceiling and wall blocks; non-reinforced concrete and compacting. (2) Materials—covering binders; additions; reinforcing steel; ceiling and roofing blocks; testing. There are 161 diagrams, 73 tables and also an explanation of the standardised symbols used in connection with reinforced-concrete work.

Théorie et Pratique du Séchage Industriel. By PAUL RAZOUS. Sixth edition, revised and enlarged. *Dunod,* 92 *Rue Bonaparte, Paris* 6*e.* (2,450 francs.)

The present sixth edition of "Industrial Dehydration in Theory and Practice," takes into account developments in thermodynamic principles, and calorific radiation or partial vacuum, as applied to dehydration. The subject is treated with a view to assisting users to increase the yield of existing or proposed plant and to enable qualified constructors to perfect old types of industrial driers and bring out new designs adapted to requirements. Various types of drying plant and their principal uses are discussed, and the essentials for satisfactory operation are given as well as the method of calculation for establishing an approximate basis for designing. This is followed by a study of the principal drying methods for raw materials, products in course of manufacture, and products from which a part of the water content has to be extracted. This study is not intended to deal exhaustively with all products submitted to dehydration but it deals with a sufficiently wide range of types to guide users of such plant in their research investigations into the most suitable type for a specific purpose. Diagrams are provided to illustrate the text.

Élasticité et Anélasticité des Métaux. By C. ZENER. *Dunod,* 92 *Rue Bonaparte, Paris* 6*e.* (2,280 francs.)

The book under the above title is a translation of the original work "Elasticity and Anelasticity of Metals," published in the U.S.A. It is a monograph for physicists, metallurgists, engineers or research workers interested in metal physics. Assuming that all readers would probably not want to study the mathematical development of the theory, the author adopts a style permitting theoretical studies to be omitted without the physical aspect of the subject being lost. Internal friction, elastic after-effects, plasticity, creep, and variations in the modulus of elasticity with the frequency of vibration are examined, and the author shows how these effects are associated and how they are explained by the mechanism of plasticity. After reviewing important works on the elasticity of metals, a theory of anelasticity is developed. The second part of the work is devoted to the physical nature of different relaxation phenomena. Numerous facts and explanations are provided on the divergence between the mechanical properties of metal and those of the perfect monocrystal.

The Railway Engineers. By O. S. NOCK. *B. T. Batsford, Limited,* 4 *Fitzhardinge-street, Portman-square, London, W.*1. (18*s.*) (Reviewed on page 169, in the issue of August 5.)

Commercial and Technical Libraries. The Library Association Series of Library Manuals, No. 10. By J. P. LAMB. *George Allen and Unwin, Limited, Ruskin House,* 40 *Museum-street, London, W.C.*1. (21*s.*). (Reviewed on page 169, in the issue of August 5.)

UNWILLING PARTNERS

THE EMPLOYER'S DUTY TO ENFORCE SAFETY MEASURES

It is well-known that people are often more careless of their own safety than they would be of the safety of others; it is principally for this reason that the law imposes upon employers a positive duty, in many cases, not only to make it possible for their workmen to look to their own safety, but also to see that the men actually comply with the measures prescribed for their own protection.

Employers are then often placed in something of a dilemma when, knowing that they are under this duty to take certain steps for the safety and health of their workmen, they find themselves faced not only with indifference, but in some cases active opposition from the men themselves.

This gives substance to the complaint of employers that when they have done their best for the safety of their men by providing all the proper apparatus for their protection, the employees themselves neglect or refuse to co-operate and, after sustaining injury in a resulting accident, are able to sue the employer successfully for breach of duty.

What is sometimes overlooked, however, is that this is only a part of the truth: if the man himself has been deliberately careless, he is often made to share equally in the cost, and recovers no more than a proportion of his damages from the employers. Furthermore, no employer is ever made to pay compensation to any of his men unless it is shown that the employer, or someone for whom he was responsible, was at fault somewhere.

OUT OF PROPORTION

Of course, the cost of the mistake or neglect may be out of all proportion to the moral blame, but that is an incident of the general law of this country, and any other person who is successfully sued in the courts of this country similarly pays to the injured claimant not in proportion to the enormity of the offence, but merely according to the actual damage suffered.

The cases which fall with most hardship upon the employer are, of course, those in which the duty cast upon him is the most strict. Some sections of the Factories Act are quite unequivocal and permit of no modification in compliance with them, or excuse for neglect. Under section 14, for instance, there is an absolute duty upon the employer to fence all dangerous machinery, and the employer must comply with this section, if necessary even to the point where, as was illustrated before the House of Lords only recently, the machinery becomes commercially unusuable.

It is not only under the Factories Act, however, that the employer's duties are strict: he has a duty to his workmen to ensure that any system of work in operation at his premises is a safe one; if there is work which might contain dangers for his men, he must ensure that proper measures for their protection are not only prescribed, but actually carried out.

Only a year or two ago a lawsuit arose out of the contraction by a workman of dermatitis from the use of synthetic glue. It was well known that the use of synthetic glue led to dermatitis unless certain precautions were taken, and these precautions included the use of a protective cream, which had to be applied to the skin each time after washing. Notices to this effect were exhibited in the workroom, and the cream was made available to the men through the store, though it was not actually in the workshop.

When the workman sued his employer for damages for contracting this illness the employer was held to be in fault in not taking positive action to encourage the men to make use of the cream. When the matter came before the Court of Appeal one of the Judges there had this observation to make: "Where an employer is making use of a dangerous process, it is not enough for him to have available somewhere in the factory the appliances necessary to minimise the danger. The system of working must be one in which the appliances are available at the place where they are needed, and the man in charge of the work should be responsible for seeing, as far as he can, that the workers make use of the appliances provided."

In this case, the workman, who knew of the danger of illness from the notices exhibited, was awarded only half the assessed loss from the illness.

POSITIVE OPPOSITION

Such is the position, then, when the men are merely neglectful of advice and instructions, and the employer himself does not seem to have taken all the steps he could have done to ensure that the proper precautions are observed. Sometimes, though, the question is not merely one of neglect on both sides, but of positive dislike on the part of the workman of the apparatus provided, a dislike which does not hesitate to manifest itself in open opposition to the measures suggested.

Men working at a height above ground regard themselves as safer without safety belts than with them, or masks for protection against dust are not worn because of the physical discomfort of wearing them, especially in heat, and no amount of warning and advice seems of avail. Little short of dismissal of the man concerned, in fact, with all its attendant possibilities, seems at times likely to induce the others to comply with the regulation.

What is the employer to do then? Merely to go on breaking the law or neglecting his duties in the hope that no accidents will happen?

If the duty is one of those enumerated in the Factories Act, the answer to this question will be found in the language of the statute itself; if, on the other hand, the duty is one which arises under the common law, and is implied in the relationship of employer and employee rather than expressed in any part of the law to be found in writing, the standard of duty imposed may be summarised in the proposition that the employer must guard against what is actively dangerous, and take all reasonable steps against any possible causes of injury where these are known or can be reasonably foreseen.

Two recent cases arising out of injury to foundry workers will perhaps serve to illustrate the limits of the employer's duties in different circumstances: in the first case the workman was unsuccessful in his claim, while in the second neglect of duty was established against the employer.

A workman who had been employed in an iron foundry in a number of capacities, mostly concerned with shovelling sand and acting as "slinger" for the shot-blaster, was discovered after a period of some eight years' employment to be suffering from pneumoconiosis, which had apparently been contracted during the first two or three years of his employment.

The apparent cause of the disease was fine particles of dust which rose through the grill over which the man was working, and through which he shovelled the sand. The employers had realised the unpleasantness and discomfort caused by this dust even before its connection with various diseases had been definitely established, and quite early in the man's employment had discovered a new system of sucking away a considerable proportion of the dust by creating a down draught below the grill through which the particles were rising.

In these circumstances it was a little difficult for an allegation to be made on behalf of the workman, when he sought to recover compensation for his illness from his employers by an action at law, that they had been guilty of some act or neglect which had caused his injury. It was suggested, however, that the employers were at fault in not having installed the system earlier, and reliance was placed on Section 47 (1) of the Act of 1937, which provides as follows:

"In every factory in which, in connection with any process carried on, there is given off any dust or fume or other impurity of such a character and to such an extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, all practicable measures shall be taken to protect the persons employed against inhalation of the dust or fume or other impurity . . ."

The High Court Judge who tried the action did not consider, however, that the employers had neglected their duties under this section. "All practicable measures," he said, means all measures which are practicable when account is taken of the contemporary state of knowledge of the dangers and precautions possible. The employers here invented or discovered a new type of air-and-dust extractor which is of benefit to the community, and it cannot be suggested against them that it was negligence not to have discovered such a system before.

In addition to the dust extractor, the employers had tried to introduce masks, but had found it impossible to persuade the men to use them. The Judge held that they had in consequence discharged their duty to take "all practicable measures," and the workman's claim for damages did not succeed.

The success of the employers in this case may be contrasted with the failure of other employers in somewhat similar circumstances, when a claim by one of their workmen for damages for his contraction of silicosis at work came before the Judge at Liverpool Assizes more recently still.

NEGLECT PROVED

In this case the workman was discovered to be suffering from the disease after a period of some 20 years at work in a steel foundry. He had been engaged throughout this period in a number of processes involving the use of sand. The disease was apparently contracted after some ten years of work, at about the time when the employers first provided masks for the protection of their workers on dusty jobs, but some three years before the specific danger of silicosis was recognised.

Later on, when the danger was realised, the employers increased the number of masks in their stores until there were sufficient for all their workmen, but, although the foundry manager spoke to the men from time to time and encouraged the use of masks, very few men in fact used them.

When the case came to court the Judge held that this was not a sufficient discharge of the duties cast upon the employers. Their attitude, he said, seemed to be summed up in the minutes of a meeting some ten years previously, and can to all intents and purposes be expressed as: "We have provided the best masks we have been able to obtain: what a pity the men don't use them!"

This is not the taking of "all practicable measures . . . to protect the person employed against the inhalation of the dust . . ." which the Act prescribes as the duty of the employer. "There was a failure," said the Judge, "to press on the men's representatives with earnestness and ardour, the need for these masks . . ." Only in this way is the employer discharging his responsibilities.

On this question of wearing protective masks, (or of course, some equally effective alternative measures) the duty of the employer is high. The words of the Act are, as may be repeated here once again, to take "all practicable measures."

On other occasions, of course, the specific words of the Factories Act do not impose so much upon the employer. Fettling is one of the processes which have been brought within the scope of Section 49 of the Factories Act, and there is therefore a duty on the employer, in accordance with the wording of this section, to

" provide suitable goggles " for the protection of the eyes of those engaged upon such work. But the language of the section stops short, it will be noticed, of imposing any other duty on the employer, than that of merely providing the goggles. Perhaps because the danger is more obvious and there is less resistance from the men themselves to the use of this form of protection, the employer has done his part when he sees that they are available.

Employers sued recently for breach of this section were successful in the defence of the action by showing that they had, in the opinion of their experts, selected the best goggles of those available for their men. A workman who was wearing a pair of the goggles was holding them an inch from his eyes and cleaning them with his finger and thumb, because they had misted up, when he sustained an eye injury from a splinter, which apparently came from the work of a fellow worker. It was alleged on his behalf that the goggles were not suitable because they were liable to mist up, but this claim failed, as did too the allegation that it was the duty of the employer to see that the man's eyes were kept safe by the goggles.

In this instance the duty of the employer under the Factories Act appears to stop short even of ensuring that the goggles are being worn, though it is quite possible that neglect would be alleged against an employer who habitually permitted his men to leave their eyes unprotected in the performance of work such as this.

FORESIGHT AND INTERPRETATION

There are, then, several different standards of care imposed upon the employer for the safety of his workmen, both under the Factories Act and under the unwritten, or common, law of this country. The duty under the common law is to ensure that no workman runs a risk of injury, so far as an accident can be reasonably foreseen. The duty under the Factories Act is not necessarily related to a risk of accident at all—some measures are prescribed merely for the physical well-being and general health of the workman.

The standard of compliance with the measures laid down by the Act depends therefore, not upon any degree of danger which the employer may be expected to foresee, but upon the wording of the section of the Act which prescribes the measure. Each expression used in the Act has its own interpretation. At the higher end of the scale there is the absolute duty to ensure that some precautions are taken: a dangerous machine must be fenced, and in some cases " effective measures " must be taken to ensure certain objects, and these duties must be carried out even at the expense of discarding a machine as unworkable or discontinuing a process altogether.

At the other end of the scale, the employer has done his duty by providing certain materials or protective devices, and has no specific duty cast upon him to ensure that they are used, though of course even then he must not countenance the running of obvious risks.

In between these two extremes of care there are a number of duties rather less clearly defined: these may be expressed with such words as " take all practicable measures," which means, broadly, acting in the light of physical possibilities and the state of knowledge of the dangers at the time. " Reasonably practicable," on the other hand, appears to impose a less strict standard: it might even extend in some cases to what is economical, though this is unlikely, and it is safer to assume that " reasonably " refers rather to the attitude of the men concerned. Unpopular means should be urged upon them, but not to the point of a dismissal or strike.

In either of these latter cases, however, the duty of the employer goes beyond merely providing the means of safety. He has a positive duty to take some steps, and not half-hearted ones at that, to see that the measures are carried out.

BROADCASTING 1954-55

V.H.F. REINFORCEMENT AND TELEVISION EXPERIMENTS

Construction and development are the keynotes of the annual report* of the British Broadcasting Corporation for the year ended March 31, 1955, which was published by H.M. Stationery Office recently. It states that full-scale reviews of the scope, resources and needs of the sound and television services resulted in the completion, of detailed five-year programmes of development in the spring of 1954; and progress was made during the year on the lines laid down in them. The number of television licences rose from 3,248,892 to 4,503,766 and the ever-increasing public demand for this service is regarded as a dominant feature of the period under review. It underlines the importance of the decision made in 1949, that the first place should be given to the establishment of a national coverage for a single television programme. That aim is within sight of achievement, since the four new medium power stations, which were opened during the year, brought some 90 per cent. of the population within range of television.

" ROVING EYE " CAMERA

Concurrently with the building of these new stations, studio facilities were extended, both in London and the provinces. The experimental " Roving Eye " camera was thoroughly tested under service conditions and proved a great success. The problems of colour television were studied to establish whether there was any system suited to British standard. It points out, however, that it would be a serious mistake to introduce colour transmissions before thoroughly satisfactory results can be made available to viewers at reasonable cost. Although the allocation of the necessary frequencies between the Corporation and the Independent Television Authority has still to be decided certain preliminary technical preparations were made.

A striking feature of the year's work was that the increase in the number of combined licences issued for sound and television was not matched by a commensurate decline in the number of licences issued for sound only. With well over nine million licences in force at the end of the period sound radio remained the major service and it is considered that with the figures as they stand it has an important future.

During the year under review the Corporation therefore pressed on with its plans for the introduction of very high frequency broadcasting as a reinforcement of the present long and medium wave systems. This is the more essential since competition in the long and medium wave bands has increased with the opening of new stations on the Continent, and interference has worsened. In fact, only by the development of very high frequency broadcasting will it be possible for the Corporation to provide improved sound transmission. The methods proposed for dealing with this problem involve the commissioning of ten stations by the end of 1956, to cover about 80 per cent. of the population. This is regarded as a revolutionary development, which presents a challenge not only to the Corporation, but to the radio industry.

ENGINEERING EFFORT

These major developments in the sound and television services, as well as in the other activities described in detail in the report, necessitated a great deal of engineering effort. As far as sound broadcasting was concerned one of the difficulties was the interference from foreign stations just mentioned. This was felt most severely in Wales, where the inauguration of a transmitter operating at the Home Service frequency of 881 kilocycles in the Soviet-controlled part of Berlin reduced the effective night-time coverage to as little as one per cent. of the population. As the result of experiments adopted at the existing stations in that area, the installation of temporary stations at Cardiff, Penmon, Towyn and Wrexham and an increase in power of the transmitter at Wrexham, operating on 881 kilocycles, the night-time coverage was restored to over 40 per cent. This was, however, a long way short of the 80 per cent. coverage which is normally obtained in the absence of any interference. These measures could not therefore be considered as more than a palliative. Similar conditions were encountered in South-East England where there was severe interference from the East German transmitter at Dresden. In the North and West Regions there was also interference from a second East German transmitter and a Rumanian transmitter, though on a less serious scale. It would therefore appear that the point is now being approached at which little or no improvement in medium wave reception can be gained by additional stations so long as they must share a wavelength; and that the really effective solution is the use of very high frequencies combined with frequency modulation.

AUTOMATIC AND REMOTE CONTROL

Increasing use was made of automatic and remote control for low-power transmitters and by the end of the year about 25 such equipments were being operated in this way. In the studios work was continued on the development of amplifiers for control desks with the object of combining the greatest flexibility with the minimum size and cost. A new ribbon microphone was also developed and a number of commercial microphones were tested. Some of these were found useful on account of their special directional characteristics. Further, improvements were made to the lip microphones used by out-of-doors commentators. The introduction of sound recording and reproducing equipment, using magnetic tape, was almost completed during the year; and this method of recording has now to a large extent replaced the use of discs. More than 120 static and mobile equipments were in use and more than 100 " midget " recorders, such as can be carried and operated by the commentator himself, were also in service.

INTERNATIONAL EXCHANGES

In addition to the planning and construction of new television transmitters outside broadcast equipment carried on self-propelled vehicles was brought into use. This resulted in a more convenient lay-out and greater freedom for manoeuvre. The experimental programme exchanges which took place between eight countries provided much valuable experience and led to improvements in the conversion equipment. Special apparatus was also designed to correct the distortion that inevitably arises in transmitting television signals over long distances. Much attention was devoted to improving the quality obtained when films are reproduced for television and when television pictures are recorded on film. Investigations were also made into the complex optical and chemical processes involved in both these operations. Work was started on the construction of a recording machine of the " suppressed-frame " type and apparatus was designed for reproducing television pictures from negative film, so as to avoid the delay in making positive prints by photographic processes. A prototype was developed of a film camera, in which the picture and sound are recorded simultaneously on two separate films, the sound being recorded magnetically.

In order to improve the external services transmmissions to South-East Africa and to the Tebrau relay station in particular, an aerial comprising 96 radiating elements was erected at the Daventry short-wave station. By using

* *Annual Report and Accounts of the British Broadcasting Corporation for the Year* 1954-55. H.M. Stationery Office, London. (4*s*. 6*d*.)

this in conjunction with two high-power transmitters an effective radiated power of 30 MW was successfully obtained. Priority was also given to experiments on television and very high frequency transmitting aerials to furnish manufacturers with information on which to base their designs. Further progress was made in devising better means of diagnosing acoustic phenomena in broadcasting studios and an investigation was made into the effects of variations in pitch and amplitude on the quality of sound reproduced from recordings. As a result it was possible to prescribe methods of measurement giving an indication of the effect of such fluctuations and to specify limits which should not be exceeded in practice.

COLOUR TELEVISION

Experimental apparatus was designed for generating television pictures in colour by using slides and films. One of the basic problems is to ensure that the special signals introduced into the colour transmission do not cause appreciable interference when the picture is seen on a monochrome receiver. A number of laboratory and other tests were made to establish this point and during the present year a series of transmissions are to be made from Alexandra Palace to enable observations to be carried out under normal viewing conditions, not only of the quality of the pictures received in colour, but also of those received in black and white on the types of receiver now in use. An extensive series of tests were made to determine whether colour signals could be transmitted satisfactorily over the existing cable and radio link networks, and much work was done on the design of transmitting aerials for television stations and on the design of the combining circuits and filters that are required.

THE ART OF HEATING AND VENTILATING*

By Neville S. Billington, M.SC., M.I.H.V.E.

It has been remarked by several authors that there appears to be some connection between civilisation and climate. Markham, for instance, has suggested that it is no accident that the early civilisations arose in the subtropical parts of the world, where the temperature and humidity are such as not to require artificial modification to enable life and work to continue. Only when artificial heating became possible did the northward march of civilisation to the temperate parts of the earth take place. Bernan, in his remarkable *History*, also suggests that the quality of heating is not without its effect upon civilised peoples. However that may be, the art of heating and ventilating is important in our present civilisation, and the story of its development is a fascinating and, at times, amusing study.

Heat emitted from the bodies of animals was perhaps the basis of the first form of artificial climate. It was still in use in 1845, for Bernan writes, "In Normandy, where the cold is severe, and the firing expensive, the lace-makers, to keep themselves warm and save fuel, agree with some farmer who has cows in winter quarters, to be allowed to carry on their operation in the society of the milky mothers. The cows are tethered in a row, on one side of the apartment, and the lace-makers sit cross-legged on the ground on the other side, with their feet buried in straw." It is interesting to note that quite recently a Swedish farmer installed a heat pump to warm his house, the heat from the cows in the adjacent cowshed serving as the source of heat.

THE OPEN FIRE

The vast majority of man's attempts to keep warm rely upon the fire, the origin of which is lost in antiquity. Legendary accounts of its discovery appear in the mythologies of many primitive peoples. According to the Ancient Greeks, fire was first brought to the earth by the god Prometheus, who stole a flame from the sun. It is probable that in fact fire was first produced by natural agencies—a lightning stroke, a volcanic eruption, or the heat of the sun's rays.

In the earliest times the making of fire was not understood, and very great efforts were made to keep alight any natural blaze which might occur. Members of the tribe (often the virgins) were appointed as keepers of the fire, and they suffered disgrace if the flame became extinguished. The making of fire by friction soon became known to some peoples, and variants of the fire-stick are still used by the more backward races. The use of flint and steel was not known until the Iron Age, but it was the best method of producing fire until the modern frictional method (the match) was invented a few centuries ago.

Both the Neanderthal man and the true man of the Mesolithic and Neolithic periods (6000–3000 B.C.) made use of fire for cooking, pottery-making and cremation. The first fires for providing warmth were probably those of the cave dwellers, while nomadic peoples also made camp-fires for warmth at night. The development of permanent dwellings led to the fire being brought indoors: houses at Corinth of 2500 B.C. had fixed hearths. Such hearths placed in the centre of the main room have been found in houses at Troy (2000 B.C.) and Thebes (1400–1100 B.C.) while they persisted in Britain until the Fifteenth Century A.D. No outlets for the escape of smoke were originally provided, but at a later stage an aperture was formed in the roof above the hearthstone.

The hearth, then, remained in the centre of the main room of the dwelling, be it cave or Great Hall, until the development of two-storey buildings made this position inconvenient. The Norman keep accordingly had wall fireplaces, and several examples are still extant. This development brought with it the need to provide some means for the escape of smoke, and in the earliest instances this was simply a short flue in the wall leading directly to outside. The origin of the chimney properly so-called is somewhat obscure. There is little doubt that the Romans made use of smoke-flues in the walls of houses, but the purpose here was primarily that of heating. It has been claimed that the first chimneys were erected in Italy; the earliest account was given in 1347. Nevertheless the distinction between the flues in Norman castles and at Abingdon Abbey (Thirteenth Century) and the chimney as we know it is slight; and perhaps we may say that the idea was born in Britain.

Early chimneys were of large size—this was a consequence of the large fireplaces required for burning logs—but the dimensions have been progressively reduced in the succeeding centuries by the efforts of Savot, Rumford and Teale. The chimney was not common in small dwellings in Britain until the Sixteenth Century, when the increasing use of coal made the absence of a chimney disagreeable, while the greater use of bricks made it easier to build them. It may be noted in passing, that the importance of the position of the chimney and fireplace was realised by some architects over a hundred years ago. Brown condemned the practice of placing them on outside walls. Yet it was felt necessary to make the point again in the Egerton Report of 1945.

The fires on the central hearth and in the early wall fireplaces were simply heaps of fuel. It was Savot who introduced the grate, in 1600. In due course, fire baskets were made, and the manufacture of iron firebacks was an important part of the work of the Sussex forges in the late Sixteenth Century. About this time conscious effort was made to improve the performance of the open fire. One of the first to attempt this was Savot in France in 1624. His grate in the Louvre in Paris supplemented the radiation by air-warming. He introduced room air to the jacket of the fire, and the warmed air was then discharged to the room through openings below the mantel. Sir John Winter, in 1658, introduced primary air for combustion direct from outside by means of a duct beneath the floor.

There followed a period of intense activity in this direction, due chiefly to Gauger, Franklin and Rumford. Rumford's work was perhaps remarkable in that it was the result of a scientific investigation into the performance of fires; and his "Rules" for the construction of fireplaces, published in 1796, have not been bettered to this day. During the century which followed, a very large number of inventions relating to open fires was made, including revolving grates, back-to-back grates, and grates with "mechanical" stoking. Hardly any survived. But we may note that downward combustion to reduce the production of smoke, the use of large ash-pits, the back-to-back grate, and convected warm air —all of which can be recognised in modern grates —were described by Bernan over a hundred years ago.

THE STOVE

The Greeks and Romans made use of braziers and altar hearths as well as the simple hearthstone. The Roman brazier was an elegant affair of bronze, on a tripod, in which was placed a round dish containing the fuel, and a small vase below to hold perfume to mask the smell of burning charcoal. Similar devices, used in Spain, were illustrated by Edwards as late as 1870. The Persian *kourcy* consisted of a jar containing fuel sunk into the earth in the centre of the room, and the mouth of the jar was covered with a board to serve as a table. A cloth was placed over all, and the occupants sat or lay on the floor with their legs beneath the cloth.

These braziers and kindred appliances were the forerunners of the closed stove. Sheet-metal stoves were in use in Europe in the Sixteenth Century. Early in the following century Kessler in Germany and Savot in France made efforts to improve the stove. Kesslar introduced the zigzag flueway, thus making more effective use of the heat in the flue gases. He also fitted primary air and flue dampers. An interesting innovation was contained in a metal stove of the Dutch or German type designed by a M. Dalesme in 1680. The flue from this stove left at the base, and the fuel burned from the top downwards—a principle now known to assist smoke consumption. The idea, however, was not widely adopted.

The massive Swedish brick-and-tile stove was also described by Kesslar. The distinguishing feature of this type was the enormous weight of material used in its construction, which served to make the heat output more uniform and to reduce the surface temperature. The stove was, and is, "a common article of furniture in Northern Europe" (Tomlinson); and was often arranged to heat two rooms and to incorporate a boiler and an oven.

In Britain the closed stove has never been in popular favour. Long and acrimonious arguments took place over the alleged overheating of the air resulting from the use of metal stoves; and the lack of ventilation afforded by a stove of either type was an additional reason for it to be discouraged, although this was not considered a demerit in Russia. As a result, the compromise of an openable stove has been developed. Although we tend to think of this as a modern development, such stoves were in fact in use in this country in the early 1800's.

Other methods of heating had been used by the Romans and the Chinese. The hypocaust will probably be familiar; it consists of a chamber

* Paper presented at the Summer Meeting of the Institution of Heating and Ventilating Engineers on June 21, 1955. Abridged.

beneath the floor of a house, through which combustion products were suffered to pass. The hypocaust was clearly the first floor-panel heating system. The Chinese *kao-kang* was essentially similar, and is still in use to-day. A massive stove placed in the centre of the house is used for both heating and cooking. The combustion products are taken beneath a raised portion of the floor and thence discharged. The inhabitants sit on this raised part by day and sleep upon it by night. A *tong-kang* (a very similar arrangement) was used in 1761 to heat the Orangery at Kew.

WARM-AIR HEATING

The stove gave rise to gravity warm-air heating. A classic example is that installed by Strutt in Derby Hospital in 1792. A stove was constructed within a brick chamber, to which fresh air could be supplied through an underground duct some 40 ft. long. The air, warmed by its passage through the chamber, was led by ducts to heat various parts of the hospital. Further air-ways were provided for the escape of the vitiated air. In the U.S.A. warm-air heating continued in favour, and its use has extended following the introduction of electrically-driven fans. In Britain, on the other hand, the method fell into desuetude about 1900, and has only recently been revived, on a small scale, as a forced-circulation system with either direct heating or heating by means of hot-water calorifiers. The continued use of warm-air heating in the U.S.A. probably led to the introduction of the unit heater for factories.

HOT-WATER HEATING

Many of the developments I have been describing took place during the Sixteenth and Seventeenth Centuries. Hot-water heating was first suggested about 1610, though substantial development was delayed until the period 1800–1840. The arts of war gave the initial impetus, when Sir Hugh Platt proposed to use hot water to dry gunpowder (*c.* 1610). In 1716, Sir Martin Triewald successfully used hot water to warm a greenhouse; and in 1777 a M. Bonnemain heated an incubator by this means. (A bi-metallic thermostat was also fitted to Bonnemain's incubator). But not until de Chabannes' time (*c.* 1816) was hot water used to heat ordinary buildings, and in 1830 Bramah heated Westminster Hospital in this way. For many years, however, the principal use appears to have been for horticulture. For this class of work large cast-iron pipes (usually 4 in. in diameter) were used, with complete satisfaction (and indeed a better form of heating surface would be hard to devise).

Only fifteen years after de Chabannes' introduction of hot water as a heating medium, Perkins invented the high-pressure system. The earliest of these were crude in the extreme: they consisted of a closed circuit of ½-in. wrought-iron pipe, between one-third and one-tenth of which was in the furnace, and the rest in the room to be heated. No safety valve was fitted. The pipe was tested to a pressure of 2,800 lb. per square inch, but even so bursts were comparatively frequent, due to the lack of control. Calorifiers were used as the heating surface. The Perkins system, improved by the addition of safety valves, the restriction of the portion of the pipe within the furnace, and the use of ¾-in. pipe, was used for a number of important buildings during the period 1835–1910, including the British Museum, the Soane Museum, and the Guildhall, from which the system has just been removed.

I have mentioned that the usual form of heating surface was, at first, pipes or calorifiers. These were followed by box-end and siphon-end coils. The first radiator was invented in 1858 by a Mr. Tasker, of Philadelphia; and in it the wrought-iron tubes were fitted together with flanged joints, and held in place by long bolts passing through the sections. A cast-iron radiator was patented in the U.S.A. by Bundy in 1874, and three years later Gillespie (also of the U.S.A.) produced a cast-iron sectional radiator. James Keith took out the first English patent in 1882: his "Universal" radiator was cast in one piece. The early English radiators closely resembled present-day hospital radiators. Four-column radiators were coming into use during 1917; but the present thin-section, multi-column radiator did not appear till much later. During the past thirty years other forms of heating surface have appeared—the cast-iron wall-panel radiator, gilled convectors and cast-iron skirting or base-board heating sections—although they are in some instances revivals of earlier ideas.

Steam heating actually pre-dates hot-water heating in established fact, although it was not even suggested until 1745, when it was mooted by a Col. William Cook. Watt made some attempt in 1784 to warm his house and office by steam, not altogether successfully; but later in association with Boulton, several workable schemes were installed in various premises. In one of these the steam was conveyed through cast-iron pipes which also served as supports for the floor.

BOILERS

Early boilers for either steam or hot water were invariably of the saddle type, but later, cylindrical and even spherical steam boilers were used. Count Rumford experimented on this subject, and concluded that boilers should be as large as possible (minimum heat loss per lb. of water), and he also recommended the use of thin materials in their construction, preferring wrought to cast iron. In his boiler setting the flue gases leaving the combustion chamber were returned to the front end of the boiler by means of flues beneath, and then led back again to the smoke-stack through flues alongside the fire chamber. The cast-iron hot-water boiler, both independent and sectional, was pioneered in Britain by James Keith, about 1890. His "Challenge" boiler was a vertical sectional model.

Only as recently as 1905 was the output of a boiler given in B.Th.U. per hour. The earliest estimates, taken from steam-engine practice, were in horse-power, and these were followed by a specification in terms of the length of 4-in. pipe and then of the area of heating surface which could be served. Coal and coke were the usual fuels but, by 1917, gas-fired boilers were becoming more popular for heating, although the cost of useful heat was about four times that given by solid-fuel boilers. (Gas circulators for hot-water supply systems and greenhouse work had appeared some ten years before.)

HEAT REQUIREMENTS

The earliest experiments bearing on heat emission and heat loss seem to have been those of Tredgold, about 1820, who determined the rate of cooling of water in cylinders of iron and glass. The experiments were repeated by Hood some twenty years later, and he concluded that 1ft. of 4-in. pipe at 180 deg. F. emits enough heat to warm 222 cub. ft. of air at the rate of 1 deg. F. per minute. Hood was also able to make a rough estimate of the heat loss through a window: he found that 1 sq. ft. of glass would cool 1·28 cub. ft. of air at the rate of 1 deg. F per minute, with a temperature difierence of 1 deg. F. (This corresponds to a U-value of 1·54 B.Th.U. per square foot per hour per deg. F.). The design procedure was thus to compute the cooling effect of the windows, add the ventilation and so arrive at a total heating load; the necessary length of pipe could then be deduced. The design outdoor temperature was chosen in relation to the usage of the building: 25 deg. F. was recommended for buildings used only in the daytime; but for those to be heated, both by night and by day, "10 deg. F. will not be too low to calculate from."

Box, writing in 1875, was aware that heat was lost also through the solid parts of the structure. By drawing upon Dulong and Petit's work on radiation and convection, he was able to arrive at the surface conductance; and in conjunction with Péclet's data on thermal conductivity calculated the U-values for some walls, obtaining figures which were not very different from those in use to-day. He was aware of the influence of radiation transfer between the walls and showed that the transmittance of the only external wall of a room was appreciably greater on this account than the transmittance of the walls of a room which is exposed on all sides. This fact, long forgotten, is attaining greater importance with the increase in radiant heating. Box neglected the losses through the floor; and those through ceilings were felt to be too difficult to calculate.

DISTRICT HEATING

The genesis of the concept of district heating is not easy to discern. Walker (1850) suggested the possibility of a district plenum-heating system for a row of cottages near a factory. The factory engine was to drive a fan, screw or pump to force warm air along an underground trunk to which were to be connected vertical shafts to each cottage, the air finally being discharged through apertures in the skirtings. Hot-water heating was proposed by Edwards in 1870.

The first plant to be put into operation was that of the New York Steam Company in 1879, and the United States has generally remained in the fore in the practice of district heating. Vicissitudes were not unknown, for Carpenter remarks that steam heating was not financially successful in cities, all but one plant having closed down (*c.* 1895). The tide turned, however, and from 1909 onwards (when the N.D.H.A. was formed), expansion has been continuous. In line with the common American heating practice, steam distribution was largely employed, though there is now a tendency to develop thermal-electric working. In Europe a thermal-electric plant designed by Rietschel and Henneberg was erected in Dresden (1885-1901), but further development on the Continent was slow until after the first world war. Manchester, too, was early in the field, with a thermal-electric plant which began operation in 1911. No further plants were erected in Britain until after the first war, when the Dundee scheme was opened (1922). The situation then was very similar to that in 1945.

VENTILATION

The need for ventilation was probably first realised when the use of a central hearth resulted in smoke-filled rooms. The only remedy then was the aperture provided for the escape of smoke. Although windows were in use they were permanently closed, being "glazed" with horn, mica, cloth and, only exceptionally, glass. The development of the flue must have eased the situation somewhat, until the sash window was designed. It first appeared in 1300, but not until 1700 was it fairly common. The window tax has left its legacy in the small windows of dwellings and tenements almost to this day. The sash window was prone to cause draughts, when open, and many attempts were made to overcome this difficulty. A crude form of hopper window was installed in St. Thomas's Hospital in 1784; and this was followed by the use of perforated metal, louvred glass, and windmill ventilators. None was entirely satisfactory, chiefly on account of the loss of light.

During the Victorian era the ventilation of working-class dwellings became a social scandal. A great deal of attention was accorded to it by the engineers and physicians of the period, and it was also the subject of a Governmental inquiry. Compare this with modern texts, where natural ventilation of dwellings is hardly mentioned—a *volte face* which cannot be commended. The fundamentals of natural ventilation were given by Walker in 1850:

(i) Windows were to admit light and not air; ventilation should be catered for separately.

(ii) Both inlets and outlets were necessary.

(iii) Incoming air should be warmed to avoid draughts.

(iv) Inlets and outlets should be well distributed.

(v) Ventilating openings should be permanent, realising that once closed, they will remain closed.

It is doubtful whether these principles could be improved upon to-day. Walker himself proposed

to use the wall cavity as an intake shaft, thus ensuring some warming of the air, while the later Tobin tubes had the same purpose. The ubiquitous air-brick has displaced them all, but it cannot be said to function better.

Quite early in the practice of ventilation it was realised that it was unsatisfactory to rely solely upon wind forces, and accordingly other methods were tried. In the Sixteenth Century Agricola ventilated a mine by lighting a fire at the base of the shaft. The idea was not applied to buildings until 1723, when Desaguliers used a fire to assist the ventilation of the House of Commons. Although mechanical fanners were used in the interim, Dr. Reid again used thermal means in his scheme for the House when it was rebuilt in 1836. De Chabannes utilised the heat from the gas chandeliers to ventilate Covent Garden Theatre. But with the perfection of the electrically-driven fan, all other means of assisted ventilation have vanished.

The first estimates of fresh-air requirements were made in the late Eighteenth Century, and were based on measurements by Prout, Davy, Pettenkoffer and others, who determined the CO_2 content of respired air and the water vapour evolved in the breath and through the skin. Hood used the latter data to estimate the quantity of air needed to carry off the water vapour, arriving at a figure of 3½ to 5 cub. ft. per minute.

Dr. Reid formed the opinion that 10 cub. ft. per minute per person was required, on the basis of "an extreme variety of experiments made on hundreds of different constitutions, and also in numerous assemblies and meetings." He recounts that about fifty members of one of the Royal Society clubs in Edinburgh "dined in an apartment I had constructed, where though illuminated by gas, the products of its combustion were essentially excluded, as they were all removed by a ventilating tube connected with, but concealed in, the drop of the gothic pendant in which the central lights were placed. Large quantities of a mild atmosphere were constantly supplied and passed in quick succession through the apartment throughout the whole evening, the effect being varied from time to time by infusing odoriferous materials, so that the air should imitate successively that of a lavender field, of an orange grove, etc. Nothing very special was noticed during the time of the dinner by the members; but Mr. Barry, of the British Hotel, who provided the dinner, and who, from the members of the club being frequently in the habit of dining at his rooms, was familiar with their constitutions, showed the committee that three times the amount of wines had been taken that was usually consumed by the same party in a room lighted by gas but not ventilated—that he had been surprised to observe that gentlemen whose usual allowance was two glasses took, without hesitation, as much as half a bottle—that those who were in the habit of taking half a bottle, took a bottle and a half, and that, in short, he had been compelled twice to send hackney-coaches for additional supplies during dinner, though he had provided a larger supply than usual, considering the circumstances under which the members met."

Nowadays, the ventilation of many classes of buildings is governed by legislation. The growth of this has been extremely rapid; for in 1921 Raynes wrote, "In Great Britain there has been no legislation to enforce a given standard of ventilation for public buildings. This is most unfortunate: for the heating and ventilation of these places is often notoriously bad . . . (it is) high time a certain standard of purity was enforced by law" for theatres and cinemas.

THE FAN

The fan itself was devised by Desaguliers in 1734. His original model was no more than a paddle wheel 7 ft. in diameter with radial blades 1 ft. wide rotating in a concentric casing. This operated in the House of Commons for many years (till 1791). Little development took place during the next hundred years. But in 1844, Ure illustrated a scroll casing; and in 1860 Guibal introduced his "chimney"—an expander section attached to the delivery port of the fan. It is not known when curved blades were first introduced; but they were occasionally employed by 1844.

By 1912, when Barker wrote on *Heating*, the fan laws were known; and Barker worked out the manometric, dynamic and total efficiencies of a fan, using the concept of "equivalent orifice." There seems to have been no important development in centrifugal fans (apart from detailed improvements, such as in manufacturing tolerances) since Ser's original multi-vane fan.

In 1834 a M. Motte received a prize for the application of the Archimedean screw in place of a fanner, and this was used for a time in Belgium and elsewhere. Some years later Mr. Combe, of Leeds, used a double-threaded screw, which can perhaps be regarded as the first axial-flow impeller. The screw soon fell into disuse, and interest in this form of impeller did not revive until the 1930's.

The noise production by fans has always been a problem. Reid noted that the noise from small fanners running at high speed (1,000–2,000 rev. per minute) was "penetrating and oppressive." For ordinary ventilating work he found it most economical to use large fans, up to 20 ft. diameter, running at low speed. This is still the practice to-day where extreme quiet is essential.

AIR-CONDITIONING

Air conditioning has grown up from warm-air heating, the provisions for cooling, cleaning and altering the humidity being additional refinements. As far as cooling is concerned, the use of *punkahs* and *tatties* has long been known in hot countries. The *punkah* maintained a satisfactory air movement; while the *tattie*, a form of moistened matting over the doorways and window openings, served to cool the air by evaporation of the water. Bernan records that indoor temperatures were often 20 deg. below the outdoor temperature, but he adds that even lower ground temperatures were available, and better results might have been possible by the use of underground tunnels to supply the ventilating air. Such a scheme was used in Venice in 1661, by Strutt at Derby, and in one of the House of Commons schemes.

Vallance is said to have devised a plenum scheme in which either heating or cooling could be provided. Dr. Reid, in 1848, proposed to circulate cool well-water through the steam heating pipes of the Commons chamber. About the same time, ice was also used for cooling air, one of the first applications being by Dr. Gorrie in a hospital in the U.S.A.

Artificial humidification of ventilating air was first attempted by Reid in the House of Commons in 1836. "A chamber was provided for moistening, drying, cooling, and producing other alterations in the air, besides those effected by the hot-water apparatus." The air was filtered through a veil, 42 ft. long and 18 ft. 6 in. deep, and it was introduced into the chamber through nearly a million holes in the floor.

With the growth of the textile industry, direct water or steam injection was tried, and these three methods have remained substantially unaltered for a century.

Dehumidification was more of a problem and, apart from that resulting when ice was used for cooling, no progress was made until Willis Carrier developed his dew-point control system in 1902, when a paper mill in Brooklyn was so equipped. Carrier's system was, of course, dependent upon the availability of mechanical refrigeration. The alternative method of dehumidification, by solid absorbers, was first suggested as recently as 1925, the inventor proposing the use of silica gel.

Recent air-conditioning and ventilation research and practice has seen the introduction of chemical additives for deodorising or as bactericides. It is perhaps not so well known that Reid was first here also. For air purification in large cities he adopted the following measures: (i) exclusion of soot by filtration, (ii) washing, (iii) washing with lime water, and the addition of ammonia (to neutralise acids), (iv) addition of chlorine or nitrous oxides to decompose animal or vegetable matter, (v) warming by steam or other means.

For special purposes he proposed further treatment of the air. Among the additives suggested were nitrous oxide, nitrous and nitric acid fumes, chlorine, sulphurous fumes, acetic acid, arsenical, prussic, mercurial, alcoholic, ethereal and benzoic fumes, and various aromatics like camphor, creosote, and oils of lavender, orange and cinnamon.

Mechanical refrigeration developed rapidly after Vallance's patent in 1824 for a sulphuric-acid absorption process and Perkins' sulphuric-ether machine (1834). About 1890 Vollman and the Linde Canadian Refrigeration Co. installed an air-cooling plant with brine-washed coils in the palace of an Indian Rajah. A 10-ton machine had been installed two years previously in an American factory to cool air for the process.

In presenting this short and very incomplete survey of the development of heating and ventilating, it has been my endeavour to select a few of the more important advances for notice. It may well be that in another century our present ideas may provoke mirth; though it is to be hoped that the transition from an art to a science has enabled us to ensure a sound basis for modern techniques.

* * *

RECLAIMING LAND AT SHELL REFINERY

£150,000 River Improvements at Stanlow

At Stanlow oil refinery, Cheshire, belonging to Shell Petroleum, Limited, work is now in progress on straightening the River Gowy which flows through the site, under the Manchester Ship Canal and into the estuary of the River Mersey. The winding 3,250 ft. of the river within the refinery is being shortened by 1,000 ft. by cutting across the river loops. Begun in March this year, the operation is scheduled for completion early in 1956. Total cost is estimated to be £150,000.

With every increasing requirement for refinery expansion, especially in the area near the river, the advantage of reclaiming land is readily apparent. The present flood banks along the sides of the Gowy are, on an average, 250 to 300 ft. apart and the planned reduction in width, together with the straightening of the river, will enable the owners to recover about 11 acres of land. The new channel will have a bed width of 15 ft., widening to about 75 ft. at the top, and will be protected by flood banks 125 ft. apart. These are to be built to a height above the highest tide so far recorded in the Mersey, which occurred in November, 1905.

The new course, like the old, will pass under the Manchester Ship Canal, through two 12-ft. diameter siphon pipes, into the sea. Before excavation work could begin it was necessary to clear several buildings, railway tracks and roads and also to re-route numerous electrical, water and firemain services and drainage outfalls. Excavation of the diversion is being carried out "in the dry" by dragline excavators. Each of the river loops will be cut off in turn and the final break-through made at convenient states of the tide to bring the river into its new course. The existing channels will then be blocked off by stone pitched banks protected from the scouring action of the river by sheet steel piles.

In all some 40,000 cubic yards of alluvial mud, clay and peat will have to be dug out and deposited in the low-lying mud flat areas and in the old river bed. This quantity will be insufficient to fill the old channel and about 70,000 cubic yards of material will have to be brought in before final grading of the area can be completed. In addition, 32,400 tons of stone filling and 11,500 ft. of sheet steel piling will be required to build the cut-off banks for sealing the old channel.

AUSTRALIAN AERONAUTICAL RESEARCH LABORATORIES

WORK ON HIGH TEMPERATURE ALLOYS AND TURBINES

We give below a summary of the annual report for the year 1953-54 *of the Aeronautical Research Laboratories of the Australian Department of Supply. The Melbourne laboratories comprise four divisions—structures, materials, aerodynamics (subsonic and transonic) and mechanical engineering, with extra-mural work in aerodynamics, structures and computation also carried out at Sydney University. There is also a high-speed aerodynamics division located in Salisbury, South Australia.*

The work of the Structures Division falls naturally into three categories—structural safety, mainly concerning the behaviour of the airframe under dynamic or fluctuating loads; design investigations, aimed at improving the efficiency and simplicity of aircraft structures; and *ad hoc* and development projects undertaken for the aircraft factories, the R.A.A.F., the Department of Civil Aviation, and the civil airlines.

MATERIALS

In the Materials Division the main emphasis during the past year has been on determining the properties, including brittleness and creep, of chromium and its alloys, with a view to their use under high temperature conditions. Another important group of projects has been aimed at elucidating the mechanism of fatigue of metals. They include the fundamental studies of " dislocations " and the deformation of metals under static stresses, which are basic to the understanding of fatigue. In addition the Division has been working on the properties of aluminium alloys, residual lattice strains in metals and on various aspects of corrosion.

High Temperature Materials.—Hot hardness testing has now given way to compression creep testing as the main method of assessing high-temperature properties. Work has been concentrated chiefly on the two cast chromium alloys containing 14 per cent. titanium and 36 per cent. tungsten respectively, the standard test temperature being 900 deg. C. These materials have shown a very satisfactory level of creep resistance, confirming the previous indications of the hot hardness test. The method of creep testing has proved generally satisfactory, although there remains room for improvement in the accuracy of strain measurement at low creep rates and in temperature control.

Considerable attention has been paid to the technology of chromium alloys and limited success has been obtained in attempts to hot-work these materials by methods similar to those which have proved satisfactory with pure chromium. However, no material with proved high strength at high temperature has yet been found amenable to working and alternative methods, e.g., extrusion, are under consideration. A significant point is that the workable alloys can be made ductile at room temperature.

Properties of Alloys.—Notable progress has been made on the problem of the room temperature brittleness of chromium, hitherto considered a major obstacle to the practical application of these alloys. Chromium has been produced showing up to 15 per cent. elongation in a room-temperature tensile test on a small specimen (ultimate tensile strength 74,500 lb. per square inch) and corresponding bending ductility has been developed in swaged rods up to 0·135 in. diameter.

It has been established that heating chromium in nitrogen at as low a temperature as 700 deg. C. produces brittleness, and the depth of embrittlement increases with time of heating in nitrogen at a particular temperature. Heating in pure oxygen at such temperatures does not substantially reduce ductility. It appears that cold rolled chromium becomes completely brittle when the nitrogen content is increased to approximately 0·02 per cent., and this amount of nitrogen is largely present in solid solution.

AERODYNAMICS

Research in the Aerodynamics Division at Melbourne has been mainly in the field of boundary layer control and some progress has been made with control of separation both at the nose and at the rear of a wing. Theoretical work on transonic and supersonic flow has also been done. A good deal of effort is being concentrated on missile development, and a new field of work, helicopters, has been initiated. There is clearly a need for transonic tunnel facilities in Australia, and some experiments have been made in order to give design data for the conversion of the variable pressure tunnel which at the moment is limited to high subsonic speeds.

The work in the 9 ft. by 7 ft. wind tunnel during the year has covered aspects of aircraft and helicopter design, mortar bombs, missiles and missile recovery, in addition to general aerodynamic problems.

Local design of a 5-place tandem-rotor helicopter has commenced. The full development of the design will be done on $\frac{1}{7}$ scale and $\frac{1}{4}$ scale wind tunnel models.

The variable-pressure tunnel has been operated for the first six months as a solid-walled conventional tunnel, and for the last six months as a two-dimensional slotted tunnel. Two different slot types have been used, but it was not possible to exceed a Mach number of 1·0 with a model in the tunnel, due to lack of fan pressure ratio and power.

Both wind tunnels now produce experimental data at such a rate that mechanised computing is essential and it has now been decided to instal " Hollerith " punched card equipment. This will in the first instance use data punched by hand from balance readings and film records, but later it is proposed to mechanise the balances and film readers to feed the data direct to the electric punch.

MECHANICAL ENGINEERING

The work of the Mechanical Engineering Division is mainly concerned with the solution of problems encountered in the design and operation of power plants; most of the effort has been on combustion research, and both turbines and ramjets have been worked upon. Work has also been done on the design of compressor blading and on air intakes for supersonic flight. Problems involved in burning brown coal in industrial turbines have been investigated. The Division is also responsible for all flight research, and the development of flight instrumentation.

During the year, the high-pressure combustion test house has been brought into commission.

In its present stage of development, experiments may be made on combustion chambers at air flow rates up to 10 lb. per second and pressures between atmospheric and 140 lb. per square inch absolute; using an ejector pump system it is also possible to work down to one-third of an atmosphere at an air-flow rate of 1·5 lb. per second.

This range of conditions will enable a series of useful experiments to be carried out, especially in the field of maximum intensity burning, but it will soon be necessary to provide means for heating and cooling the combustion air in order to simulate more closely aircraft operating conditions. In this way experiments will be possible on relighting and flame stability under simulated atitude conditions.

Plans for another test house have been completed and building should start during the coming year. In this test house two rigs are for ramjet investigations and the third for work on a high speed cascade tunnel. Air from both the 2,000-h.p. and the 3,500-h.p. compressors will be fed into this building.

Experimental work on ramjets includes an investigation of the fuel distribution and droplet size in a 12-in. diameter circular duct and the setting up of a ramjet-type combustor for the investigation. A method for photographing droplets moving in an airstream at 250 ft. per second has been developed.

Research is also in hand on the problem of developing an efficient and stable intake system for engines operating at Mach numbers of 2 and above, and the construction of a rig for investigating flow instability in ramjets is well advanced.

Brown Coal-Burning Gas Turbine.—It can be now said that a combustor fed directly with " fluidised " coal can be made to operate at high efficiency and with little loss. This " direct " injection system greatly decreases the size of the auxiliary plant and pipe lines compared with mechanical coal-handling systems; it increases the regularity of the fuel feed and enables it to be controlled in a simple manner.

The work is being extended to a combustor operating at 3 atmospheres pressure and the system so developed will be applicable directly to an industrial turbine. Methods of charging the fluidiser continuously rather than by batch operation are being investigated.

A ten-fold reduction of ash build up with a typical brown coal has been obtained by washing the coal with water prior to crushing. Thus a possible way of preventing deposition is by the use of chemical additives.

If finance permits it is planned to set up an industrial gas-turbine and run it on brown coal. This proposal has the support of the Australian Gas Turbine Research Committee.

High Temperature Gas Turbine.—The specific power of the gas turbine is limited by the maximum temperature to which stressed metal parts, particularly the rotating blading in the turbine, can be subjected.

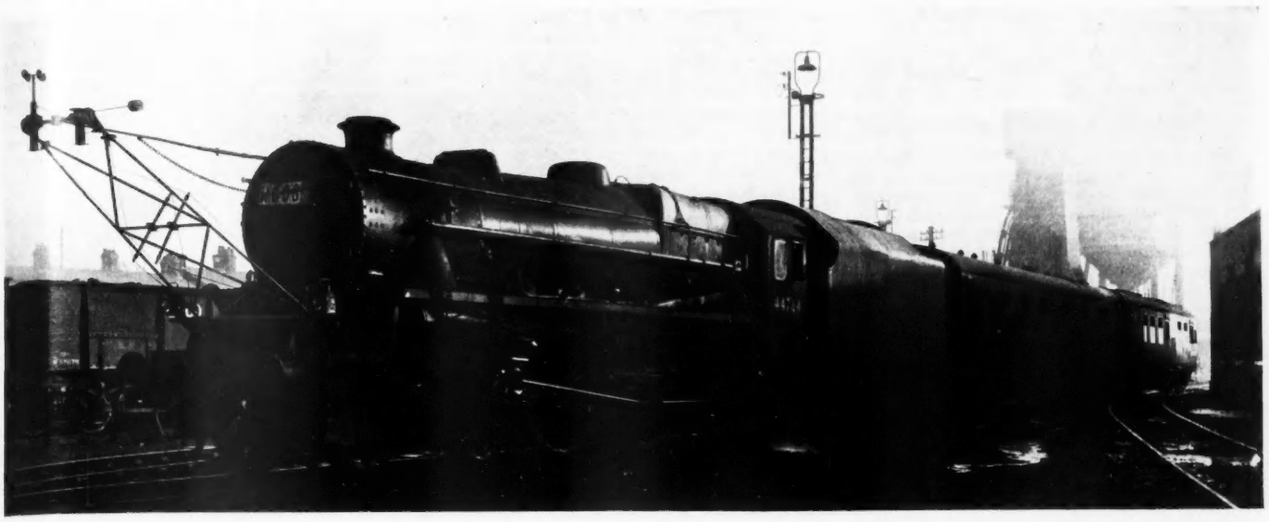
The chromium-base alloys under development in the Materials Division may retain their strength sufficiently to enable the gas-turbine to operate at higher temperatures; preliminary work is now in hand on a static rig which will permit tests to be made on typical turbine blade shapes loaded in tension and subjected to gas loadings and heat shock.

HIGH SPEED AERODYNAMICS

At the High Speed Aerodynamics Division at Salisbury, work continues in three main directions; the construction of supersonic wind tunnels; aerodynamic research by the free flight model method centred on wing drag, intake aerodynamics and flutter investigations; and the development of guided weapons. Theoretical work in the field of high speed aerodynamics is also proceeding and a shock tube for supersonic flow studies is in operation.

Supersonic Wind Tunnels.—Construction of the supersonic 15-in. by 15-in. continuous tunnel for speeds from Mach 1·5 to 2·6 has been subject to some delays. Since the adjustable diffuser may not be completed when the tunnel is ready for running, provision has been made for temporary operation without it; this will entail some curtailment of the tunnel operating range on account of the comparatively inefficient pressure recovery.

The instrumentation section which designs, develops and constructs special purpose instruments and optical, electronic and mechanical devices for the rest of the Laboratory, has constructed a compact sheared-wave interferometer for use with the shock tube which has proved quite successful optically; there has been difficulty in providing a high intensity short duration flash. Other equipment built during the year includes a sighting system for checking the ways of a die-sinking machine used for the construction of wind tunnel nozzles and models.



Stationary test on a 4-6-0 locomotive to ascertain the boiler losses due to radiation. A dynamometer car and a mobile testing unit were employed.

HEAT LOSSES OF LOCOMOTIVE BOILERS

MEASURING THE EFFECTS OF RADIATION AND EXHAUST-STEAM INJECTORS

By H. I. Andrews, PH.D., M.SC., M.I.MECH.E., M.I.E.E.

The generally accepted method of calculating the heat balance for a locomotive boiler depends on an assumed value for radiation losses. An investigation carried out on British Railways, and described in this article, has shown that the actual losses are appreciably less. A method of making due allowance for an exhaust-steam injector is also described.

To determine the performance of a locomotive boiler it is merely necessary to measure the coal consumed, the water evaporated, and the temperature and pressure of the steam produced, at different rates of working, so that a relationship may be established between the rate of fuel used and the equivalent rate of evaporation of steam from and at some particular temperature, usually 212 deg. F. If, however, it is desired to study the working of the boiler in detail, it is necessary that the various thermal losses of the boiler should be determined separately, so that with the amounts of heat received in the coal, and of heat given to the steam, a complete thermal balance for the boiler may be established for any rate of working.

CONVENTIONAL ANALYSIS

The losses principally concerned are associated with the escape of the hot smokebox gases through the chimney, and are therefore usually investigated by measuring the temperature of these gases on leaving, and by chemical analysis of a representative sample. From these measurements the nature and amount of the gas produced in relation to the coal burnt can be calculated, and the corresponding amount of heat so lost determined. The heat carried away directly by the dry flue gas is the product of the weight of the gas with its temperature above the ambient and with its mean specific heat. In addition, heat is also lost due to incomplete combustion, since any unburnt CO or H_2 remaining in the gases represents an effective loss of heat which could have been available in the firebox. There is also a small loss associated with the moisture in the flue gases, such moisture having been already present in the air, already present in the coal, or produced by combustion of hydrocarbons in the coal, all of which is readily calculable. The heat supplied in the coal burnt is the weight of the coal multiplied by its calorific value. A tentative thermal balance for the amount of coal burnt may therefore be drawn up as in Table I.

TABLE I. *Heat Balance for Amount of Coal Burnt*

Heat supplied in coal burnt	A	Heat lost to dry flue gas	C
		Heat lost to incomplete combustion	D
		Heat lost in moisture	E
		Heat received by boiler (by difference)	B
	A	=	B + C + D + E

As is well known, however, such a balance does not represent the whole truth since not all the coal supplied to the firebox is actually burnt: owing to the action of the draught some coal may be carried away with the flue gases as smoke or cinders. There is also a small loss due to cinders escaping with the ash into the ashpan. Assuming that all the coal taken from the tender goes through the firedoor, and that the test is so conducted that there is the same amount of coal or unburnt carbon on the grate at the end of a test as at the beginning, the coal consumed may be measured as the amount of coal drawn from the tender. To determine the amount of coal actually burnt it is necessary to know the loss of unburnt fuel through the chimney and to the ashpan, and while the small loss to the ashpan may readily be found by analysing a sample of the ashpan contents, the loss through the chimney, which may amount to as much as 20 per cent. of the coal fired, is extremely difficult to measure. Arrangements were made on the stationary testing plants of Altoona, Illinois, and Grunewald to collect the unburnt particles in the chimney flue gas during each test, but the accuracy of such a measurement is dependent upon the efficiency of the particle collection, and there is always the possibility of fine material escaping uncollected, while such means are of course quite impossible on a road test. Similarly, of the heat given to the boiler, the majority is transferred to the steam, but some portion goes to losses such as radiation and convection from the boiler, minor leakages, etc. For these reasons it has usually been impossible to draw up a complete balance sheet for a locomotive boiler.

FRY'S ASSUMPTION ON LOSSES

To get over these difficulties, Fry in 1924 produced a simple and practical means of computing the results of a boiler trial which has since been generally adopted.[1] The basis of this method is the assumption that the loss to external radiation, including leakage losses, etc., is 5 per cent. of the heat used in producing the steam, which is known; following which the amount of coal actually burnt may be obtained algebraically. Various modifications of this method have been employed, but the general principle involved may be exemplified as follows. From the gas analysis and other observations, a thermal balance in relation to each lb. of coal actually burnt may be drawn up as in Table II.

TABLE II. *Heat Balance per lb. of Coal Actually Burnt*

Heat supplied in 1 lb. coal	*a*	Heat lost to dry flue gas	*c*
		Heat lost to incomplete combustion	*d*
		Heat lost in moisture	*e*
		Heat received by boiler (by difference)	*b*
	a	=	$b + (c + d + e)$

Now let X lb. represent the unknown amount of coal actually burnt; a complete balance for the true quantities involved may be drawn up as in Table III.

TABLE III. *Complete Heat Balance*

Heat supplied in coal fired	H	Heat lost to dry flue gas	cX
		Heat lost to incomplete combustion	dX
		Heat lost in moisture	eX
		Heat given to steam ..	F
		Heat lost in radiation, etc.	0·05 F
		Heat lost with ash ..	G
		Heat lost in unburnt fuel (by difference)	K
	H	=	$1{\cdot}05F + (c + d + e)X + G + K$

Comparing Tables II and III, it is seen that the amount of heat received by the boiler, which is bX from Table II, corresponds to the heat given to the steam plus the radiation losses $F + 0{\cdot}05F = 1{\cdot}05F$ in Table III, so that the value of X may be calculated as $X = \frac{1}{b}(1{\cdot}05F)$. Knowing the value of X, the remaining values

may be inserted in Table III, and the heat lost in unburnt fuel K obtained by difference.

While this method may appear indirect, its results are by no means indefinite, because if the value of X be written as derived, $X = 1{\cdot}05F\left\{\frac{1}{a-(c+d+e)}\right\}$ it is seen to consist primarily of the values F and a which may be directly measured with accuracy, corrected by the smaller values c, d, and e, which are directly calculated from the observations. The constant 1·05 is, however, dependent upon the assumption made for the radiation loss, which assumption therefore affects the result in the ratio of the radiation loss to the heat given to the steam. Since the heat lost in unburnt fuel must again be determined by difference, its estimated value is particularly susceptible to errors in these quantities.

While this method has been considerably employed during the last 30 years, and has provided much information of value, it is well-known to be subject to some measure of error. It would seem that the boiler losses often tend to be exaggerated, so that, at the lower rates of evaporation, the sum of the heat given to the steam and the estimated losses may even exceed the amount of heat available in the coal fired, without any allowance for loss due to unburnt fuel. This tendency is visible even in the examples worked out in Fry's book.[1] While this effect is not so evident at the higher rates of evaporation where the loss due to unburnt fuel becomes serious, it is reasonable to suppose that the other losses are still correspondingly over-estimated.

That this difficulty was appreciated by Fry is clear from an article[2] he contributed to ENGINEERING in 1947. In addition to proposing certain modifications in the method of computation, he suggested that the estimated proportion of the radiation losses to the heat given to the steam should be 3 per cent. in place of the previously estimated value of 5 per cent., giving a constant of 1·03 in the expression for X above. Nevertheless, it has still been the general experience in this country that the Fry method, even with the reduced estimate of the radiation loss, still leads to exaggerated values for the boiler losses which are particularly evident at the lower rates of working.

RADIATION LOSSES

It was therefore decided to attempt to measure the radiation losses directly in the course of locomotive testing, and the first such measurements were carried out during tests on an L.M.R. Class 5 locomotive No. 44764 with the Mobile Testing Plant in 1950. The measurements were made in a test with the locomotive stationary and the regulator closed, the locomotive being situated in an exposed position at right-angles to the direction of the wind, and attached to the dynamometer car with one Mobile Testing Unit to provide auxiliary power. A detailed description of the apparatus employed is available[3]. Stationary conditions were chosen for this test for two reasons; firstly, because the radiation loss thus represented a much larger proportion of the energy measured, and secondly, as only a slight natural draught was required to maintain the very low rate of combustion necessary, losses due to unburnt fuel were almost completely eliminated, and could be neglected.

The procedure of the test was as follows. The boiler was first brought to its specified pressure for testing, in this case 200 lb. per square inch, when the blower was shut off and the fire on the grate reduced to a small amount which had been found by experience to be sufficient to maintain the pressure. From the start of the test small amounts of weighed coal were added to the fire at intervals in sufficient quantity to maintain the specified pressure in the boiler. As this represented only a very low rate of firing it was necessary for the test to be continued for nearly twelve hours in order that a reasonably measurable quantity of coal might be consumed. During this time the temperature of the gases leaving the smokebox was recorded, and chemical analyses of a continuous sample of smokebox gas were taken at intervals, the equipment necessary for these measurements being available in the dynamometer car. The gases left the chimney at only a very low velocity, and were entirely free from smoke, so that the possibility of any appreciable quantity of fuel escaping unburnt was remote. No difficulty was found in maintaining the boiler pressure well within the limits usually obtainable in a locomotive test. At the end of the test the fire was restored as nearly as possible to its original condition, so that the true amount of coal used during the test could be measured.

During the test it was found that the water level in the boiler continuously declined, and it was necessary for it to be restored at intervals by drawing additional water from the tender. The amount of water so taken was metered in the usua way, the live-steam injector being used and any overflow measured, so that the exact amount of water supplied to the boiler could be ascertained. Examination of the boiler revealed no external leakage of water, and very little leakage of steam, but there was appreciable leakage of steam from the cylinders and associated parts. It was therefore concluded that the whole of the water consumed escaped in the form of steam at or about the temperature of the boiler, and that the bulk of this steam had passed through the nominally closed regulator. Knowing the pressure in the boiler and the amount of water required to maintain the boiler level, the amount of heat lost through steam leakage could be calculated, and since most of this steam had passed through the regulator, this loss was not properly chargeable to the boiler.

The measurements thus obtained are given in Table IV, and a thermal balance for the working of the boiler in this condition is drawn up in Table V. The quantities of heat carried away by the dry flue gases, by moisture, or lost due to incomplete combustion, are calculated from the observations as described by Fry[1], and, there being no appreciable loss to unburnt fuel, the radiation loss could be determined by difference.

TABLE IV. *Observations of Stationary Test*

Duration of test	11 hr. 20 min.
Coal fired	492 lb.
Dry coal fired	470 ,,
Water used	1,795 ,,
Air temperature (average)	34·6 deg. F.
Feed-water temperature (average)	37·8 ,,
Firebox temperature (average)	526 ,,
Smokebox temperature (average)	334 ,,
Boiler pressure (average)	202 lb. per sq. in.
Average analysis of smokebox gases:—	
CO_2 (by volume)	3·5 ,,
CO ,,	0·67 ,,
O_2 ,,	15·70 ,,
H_2 ,,	0·05 ,,

TABLE V. *Heat Balance for Entire Stationary Test (Units: B.Th.U. × 10^6)*

Heat supplied in coal	6·29	Heat given to steam	2·14
		Heat lost to dry flue gas	1·49
		Heat lost in moisture	0·26
		Heat lost in incomplete combustion	0·03
		Heat lost in radiation (by difference)	2·37
	6·29		6·29

From Table V it is seen that a total loss to radiation, etc., of $2{\cdot}37 \times 10^6$ B.Th.U. is experienced in a period of 11·33 hours, or at a rate of $0{\cdot}21 \times 10^6$ B.Th.U. per hour. During the normal tests on this locomotive, rates of evaporation were sustained up to a maximum value of heat given to steam of $27{\cdot}9 \times 10^6$ B.Th.U. per hour, so that, under these conditions, the relation of the radiation loss to the heat given to the steam amounts to only 0·75 per cent., though it would be proportionately greater at lower rates of working. This value compares with Fry's original estimate of 5 per cent., later reduced to 3 per cent.

FLOW OF AIR OVER BOILER

Since the loss to radiation, etc., measured depends primarily upon the temperature of the boiler, and to some extent upon the relative movement of the surrounding air, there seems no reason to suppose that its value will differ appreciably with different rates of working of the boiler. Fry himself states (Ref. 1, page 36) "there does not seem to be any good reason for expecting the loss by external radiation to increase as the rate of working is increased." The one serious difference between the conditions of stationary and running tests is, of course, the flow of air over the boiler. To ascertain the effect of the wind, temperatures were measured at the outer surface of the boiler sheeting. With a boiler temperature of 390 deg. F., an ambient temperature of 34 deg. F., and a cross wind of about 10 m.p.h., the mean temperature of the outer sheeting was found to be about 125 deg. F., so that about three-quarters of the temperature drop occurs in the boiler lagging. Calculation, on a basis of Ref. 4, indicates that, of the heat lost from this outer surface, only about one-sixth is lost by convection, and that, were the wind speed increased to as much as 60 m.p.h., the total heat lost from the boiler would be increased by only about 6 per cent., while the effect of a head wind would be less. As this ultimately represents a difference of less than 0·1 per cent. in the thermal balance of the boiler in full working, it is seen that the effects of relative wind above that of a cross wind of about 10 m.p..h may safely be neglected.

This result clearly explains the difficulties which were being experienced in the use of the Fry method, since the measured value of the radiation loss is so much less than had been expected. Once the radiation has been separately determined, little difficulty has so far been experienced in obtaining satisfactory results from locomotive boiler tests.

EXHAUST-STEAM INJECTOR

The establishment of a heat balance becomes more complicated in the case of a locomotive using an exhaust-steam injector, since the quantity of the exhaust steam returned to the boiler, and its associated energy, must be determined. This implies metering the exhaust steam returned to the injector, a difficult measurement in view of the pulsating nature of the steam flow. For this reason such locomotives have sometimes been tested using the live-steam injector only. A method of avoiding this difficulty which needs only the measurement of one additional temperature has been devised, and is as follows.

Before starting the tests, a separate calibration is made on the test-bed of the discharge of live steam from the supplementary steam nozzle of the injector, which is related to its working pressure. During the tests, in addition to the usual measurements, the temperature of the water delivered by the injector to the boiler is observed so that, knowing the boiler pressure at which this water is delivered, its total energy at delivery can be calculated. Now, assuming the following nomenclature:—

—	Quantity (lb. per hr.)	Energy B.Th.U. per lb.)
Water supplied from tender	W	w
Exhaust steam supplied to injector	E	e
Supplementary live steam supplied to injector	S	s
Feed water delivered by injector	F	f

The amount of water delivered by the injector is therefore:—

$$F = W + E + S$$

Of these, W is measured by the water meter in the usual manner, and S, which is small, has been determined by calibration. It remains therefore that E must be determined.

The energy supplied to the injector by the water, exhaust steam, and supplementary live steam are wW, eE, and sS respectively, so that the total energy supplied to the injector is:—

$$wW + eE + sS.$$

Of these, w, W, s, and S are known or can be determined from the observations with the aid of steam tables. If the exhaust steam is superheated its total energy e may be determined from

is pressure and temperature; if wet, the dryness should strictly be measured, but it may be shown that, for normal values of dryness, the use of a value of e corresponding to that of dry saturated steam can have but little effect upon the value of E calculated. Similarly, the total energy leaving the injector is:—

$$fF = f(W + E + S)$$

where f, W, and S are known.

Equating these quantities

$$f(W + E + S) = wW + eE + sS$$

from which

$$E = \frac{(f - w)\,W - (s - f)\,S}{(e - f)}.$$

An additional item must therefore be included in the left-hand column of Table III to represent the "Heat returned from exhaust-steam injector," the value of which will be:—

$$(W + E + S)(f - w) - sS.$$

SUMMARY

By the use of these extensions to the Fry method, the heat losses of a boiler may be determined without making any assumption that could appreciably affect the result. It is to be noted, however, that the last item in the balance must be determined by difference, and, while there can be no objection to this practice, separate determination of all the items would enable a true balance to be obtained for each test, which is a valuable check on the accuracy of the observations. It is hoped that a method of achieving this may be available soon.

The author is indebted to the British Transport Commission for permission to publish these results.

REFERENCES

[1] Fry, L. H., *A Study of the Locomotive Boiler*, Simmons-Boardman, New York, London (1924).

[2] Fry, L. H., "Heat Balances for Locomotive Boilers," ENGINEERING, vol. 163, page 303 (1947).

[3] Andrews, H. I., "The Mobile Locomotive Testing Plant of the London Midland and Scottish Railway," *Proc. I. Mech. E.*, vol. 158, page 450 (1948).

[4] Fishenden, M., and Saunders, O. A., *The Calculation of Heat Transmission*, H.M. Stationery Office, London (1932).

★ ★ ★

ROAD CONSTRUCTION IN THE SCOTTISH HIGHLANDS

The Moriston project of the North of Scotland Hydro-Electric Board includes the construction of a dam, 2,234 ft. long and 118 ft. high, across Loch Cluanie. As a result the level of the loch will be raised and an existing road will be submerged. It has therefore been necessary to build a new road, 7¼ miles long, between the new Cluanie dam and Cluanie Inn to the west. This was opened for traffic on Monday, August 1, and a welcome improvement in the route through Glen Moriston to Kyle of Lochalsh and Skye was thus provided. When a further diversion has been constructed from Cluanie dam to Glen Garry the new road will form part of the main trunk road from Invergarry and the south to the west. The consulting engineers for the road were Sir William Halcrow and Partners; and it was constructed by the International Development Company (Nottingham), Limited, Newark.

★ ★ ★

INDEX TO "ENGINEERING"

Volume 178 now ready

The Index to Volume 178 (July-December, 1954) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36 Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

BENDING OF A STRAIGHT BEAM UNDER TRANSVERSE LOADING

IMPULSE AND STEP FUNCTIONS IN ELEMENTARY PROBLEMS

*By A. W. Gillies**

In a previous article[1] the author developed the general solution for the bending of an initially straight beam under arbitrary loading by a systematic extension of Macaulay's method. The present article makes the method more complete by adding two new concepts. The sign conventions and symbols are those of the previous article, and are summarised in Fig. 1 and in the equations

$$w = -\frac{dS}{dx} = \frac{d^2M}{dx^2} = EI\frac{d^3\theta}{dx^3} = EI\frac{d^4y}{dx^4}.$$

The normal cartesian co-ordinates are used and four successive integrations change the rate of loading w to the deflection y, or four differentiations in the reverse direction. Thus five equations arise for w, $-S$, M, θ and y, any one of the first three of which can be written down initially from the nature of the loading on the beam, and the others derived by integration or differentiation as the case may be.

The novelty of the procedure described was that, with the origin at the left-hand end of the beam, definite integrals between 0 and x were used, which brought in automatically the values of $-S$, M, θ, y at the end $x = 0$ as the constants of integration, two of these usually being known from the conditions of support. Alternatively, we may regard this procedure as using the indefinite integrals which vanish at $x = 0$, which again brings in the values at $x = 0$ of the successive quantities $-S \ldots y$ as the constants of integration.

The defects of the method are, firstly, that it becomes rather tricky to keep track of signs if the origin is not taken at the left-hand end of the beam so that x is positive along the length of the beam; and, secondly, that a concentrated load does not appear in the equation for w, but enters only in the equation for S, while a concentrated moment appears first in the equation for M. This is more a defect in elegance than a practical difficulty, but it means that all the conditions cannot be written into the first equation for w and thereafter progress made from this equation without further reference to the conditions of loading.

THE MACAULAY POWER FUNCTION

In the present method use is made of the function $\{x - a\}^n$, the significance of the curly bracket being that the function is zero if the number $x - a$ inside the bracket is negative, but is the ordinary power $(x - a)^n$ if $x - a$ is positive.

With $n = 0$ we have $\{x - a\}^0 = 0$ if $x < a$, and $\{x - a\}^0 = 1$ if $x > a$, i.e., this is a "unit step function" jumping from 0 to 1 at $x = a$. The general power $\{x - a\}^n$ may be regarded as the product of $(x - a)^n$ and this unit step function.

It was shown in the previous article that for $a > 0$

$$\int_0^x \{x - a\}^n\,dx = \frac{\{x - a\}^{n+1}}{n + 1} \quad (1)$$

n being a positive integer, or zero. The right-hand side of this equation may be regarded as the indefinite integral which vanishes at $x = 0$.

On the other hand if a is negative, the above result no longer holds.

In general, we have the differential relation

$$\frac{d}{du}\frac{\{u\}^{n+1}}{n + 1} = \{u\}^n \quad (n \geqslant 0) \quad . \quad (2)$$

* Department of Mathematics, Northampton Polytechnic, St. John-street, London, E.C.1.

If $u = x - a$ then $\frac{du}{dx} = 1$ and

$$\frac{d}{dx}\frac{\{x - a\}^{n+1}}{n + 1} = \{x - a\}^n \quad . \quad (3)$$

which is the differential form of equation (1).

If instead we set $u = a - x$, then $\frac{du}{dx} = -1$ and equation (2) now yields

$$\frac{d}{dx}\frac{\{a - x\}^{n+1}}{n + 1} = -\{a - x\}^n \quad (4)$$

or in integral form

$$\int_0^x \{a - x\}^n\,dx = -\frac{\{a - x\}^{n+1}}{n + 1}. \quad (5)$$

This is valid when a is negative, i.e., the right-hand side of equation (5) gives an indefinite integral of $\{a - x\}^n$ which vanishes at $x = 0$ when $a < 0$.

The type of function $\{a - x\}^n$ occurring in equations (4) and (5) is zero when $x > a$, and equals $(a - x)^n$ when $x < a$. Thus we have the relations

$$\{x - a\}^n + \{a - x\}^n = (x - a)^n = (a - x)^n \quad (n \text{ even}) \quad . \quad (6)$$

$$\{x - a\}^n - \{a - x\}^n = (x - a)^n = -(a - x)^n \quad (n \text{ odd}) \quad . \quad (7)$$

these relations holding whatever the value of a.

THE CONCENTRATED LOAD FUNCTION

The step function $\{x - a\}^0$ may be regarded as the limiting form of a continuously differentiable function $f(x)$, shown in Fig. 2, which is zero for $x < a - \epsilon$, equals 1 for $x > a + \epsilon$ and rises steeply along a smooth curve from 0 to 1 as x increases from $a - \epsilon$ to $a + \epsilon$. The differential coefficient $f'(x)$ is thus zero for $x < a - \epsilon$ and again for $x > a + \epsilon$ but rises to a large maximum value along a sharply-peaked curve between $a - \epsilon$ and $a + \epsilon$. The area under this curve is $\int_{a-\epsilon}^{a+\epsilon} f'(x)\,dx = \Big[f(x)\Big]_{a-\epsilon}^{a+\epsilon}$ $= 1 - 0 = 1$, the amount of the increase in $f(x)$ between $a - \epsilon$ and $a + \epsilon$.

The limiting form of $f(x)$ as $\epsilon \to 0$ is the step function $\{x - a\}^0$ and the limiting form of $f'(x)$ is a function which is zero when $x \neq a$ but is infinite at $x = a$, in such a way that its integral over any interval which includes $x = a$ has the value 1. If the interval of integration does not include $x = a$ then the integral is zero. This limiting form of $f'(x)$ is thus the function known

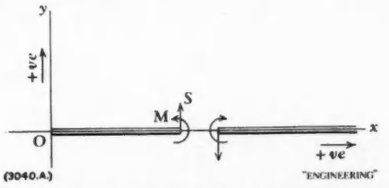


Fig. 1 A conventional system of cartesian co-ordinates and successive integration from the equation expressing the loading across the beam is used for the analysis of bending problems. To overcome the difficulties of continuity associated with distributed loads over only part of the beam and also with concentrated loads, use is made of unit step functions.

in other connections as a delta function or impulse function and denoted by $\delta(x,a)$ or, if the independent variable x is clearly understood, we may write it as $\delta(a)$.

We then have

$$\frac{d}{dx}\{x-a\}^0 = \delta(a) \quad . \quad . \quad (8)$$

and

$$\int \delta(a)\,dx = \{x-a\}^0 \quad . \quad . \quad (9)$$

the latter giving the indefinite integral vanishing at $x = 0$ when a is positive.

The function $\delta(a)$ represents the rate of loading due to a unit concentrated load at $x = a$. If we set $w = \mathrm{F}\,\delta(a)$ for a concentrated load F at $x = a$, then the total load between $x = \alpha$ and $x = \beta$ is $\int_\alpha^\beta w\,dx$, and this is F or zero according to whether the interval α to β contains the point $x = a$ or not.

The function $-\{a-x\}^0$ is also a unit step function jumping from -1 to 0 as x increases from a value very slightly less than a to a value slightly greater than a. In fact putting $n = 0$ in equation (6) gives

$$-\{a-x\}^0 = \{x-a\}^0 - 1. \quad (10)$$

We may therefore show in the same way, or by differentiating equation (10), that the differential coefficient of $-\{a-x\}^0$ is also $\delta(a)$.

Thus

$$\frac{d}{dx}[-\{a-x\}^0] = \delta(a) \quad . \quad . \quad (11)$$

and

$$\int \delta(a)\,dx = -\{a-x\}^0 \quad . \quad . \quad (12)$$

the latter giving the indefinite integral vanishing at $x = 0$ when a is negative.

THE CONCENTRATED MOMENT FUNCTION

If we consider the second differential coefficient of the function $f(x)$ of the foregoing section, i.e., the gradient of the graph of $f'(x)$, it is clearly zero outside the interval $a-\epsilon$ to $a+\epsilon$. Within this interval however it rises to a very sharp positive maximum at the steepest point of the up-slope of the $f'(x)$ graph, falls to zero at the maximum of $f'(x)$, becomes negative falling to a sharp minimum at the steepest point on the down-slope of the $f'(x)$ graph, and finally rises to zero at $x = a+\epsilon$.

Suppose now a beam is subject to a rate of loading represented by $f''(x)$. The load is zero except near $x = a$, but near this point we have a very large positive rate of loading in a very short interval, followed by another short interval in which there is a large negative rate of loading. The limiting form is clearly two opposite concentrated loads very close together.

Calculate the moment due to this loading about any point of the beam. An element $w\,d\xi$ at the point ξ will have a moment about the point x given by $-w(x-\xi)\,d\xi$ and the total moment will be given by $-\int_\alpha^\beta w(x-\xi)\,d\xi$ where $x = \alpha$ and $x = \beta$ are the extremities of the beam, so that $\alpha < a-\epsilon$ and $\beta > a+\epsilon$. Replacing w by $f''(\xi)$ this becomes

$$-\int_\alpha^\beta f''(\xi)(x-\xi)\,d\xi = -\Big[f'(\xi)(x-\xi)\Big]_\alpha^\beta - \int_\alpha^\beta f'(\xi)\,d\xi$$

on integration by parts.

The integrated term vanishes at both limits since they are outside the interval in which $f'(x)$ has non-zero values. The remaining integral is $\Big[f(\xi)\Big]_\alpha^\beta = 1$, so that

$$-\int_\alpha^\beta w(x-\xi)\,d\xi = -1.$$

Thus the moment is -1 and since this is independent of x, this loading must be equivalent to a couple of moment -1.

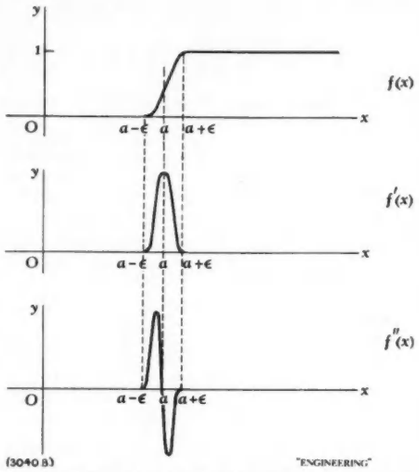


Fig. 2 The unit step function may be regarded as a limiting form of a continuously differentiable function; the form of the function and of the first and second differential coefficients of the function are shown in the three graphs.

The limiting form of $f''(x)$ which may be written as $\delta'(x,a)$ or simply as $\delta'(a)$, thus represents the rate of loading to be attributed to a concentrated couple of moment -1 at $x = a$. The rate of loading of a concentrated couple of moment G is thus $-\mathrm{G}\,\delta'(a)$.

We then have

$$\int \delta'(a)\,dx = \delta(a). \quad . \quad . \quad . \quad (13)$$

GENERAL EQUATIONS FOR THE BEAM

We are now in a position to consider the solution of any beam problem. We may write down first the equation for w, the rate of loading.

Let us suppose that there is a concentrated load F at $x = a$, a concentrated couple G at $x = b$, and a distributed rate of loading represented by $\mathrm{W}(x)$. We then have for the total rate of loading

$$w = \mathrm{W}(x) + \mathrm{F}\,\delta(a) - \mathrm{G}\,\delta'(b). \quad (14)$$

If more than one concentrated load or couple exists, then the single terms $\mathrm{F}\,\delta(a)$ and $-\mathrm{G}\,\delta'(b)$ are replaced by sums $\Sigma\,\mathrm{F}_r\,\delta(a_r)$ and $-\Sigma\,\mathrm{G}_r\,\delta'(b_r)$.

Four successive integrations will then give in turn $-\mathrm{S}$, M, $\mathrm{EI}\theta$ and $\mathrm{EI}y$ on the left-hand side and, if the indefinite integrals which vanish at $x = 0$ are used on the right, the constant of integration at each stage will be the value at $x = 0$ of the function on the left.

Thus we have, in the usual case, when the origin is chosen at the left-hand end of the beam

$$-\mathrm{S} = -\mathrm{S}_0 + \int \mathrm{W}(x)\,dx + \mathrm{F}\{x-a\}^0 - \mathrm{G}\,\delta(b) \quad (15)$$

$$\mathrm{M} = \mathrm{M}_0 - \mathrm{S}_0 x + \int dx \int \mathrm{W}(x)\,dx + \mathrm{F}\{x-a\} - \mathrm{G}\{x-b\}^0 \quad (16)$$

$$\mathrm{EI}\,\theta = \mathrm{EI}\,\theta_0 + \mathrm{M}_0 x - \mathrm{S}_0\frac{x^2}{2} + \int dx \int dx \int \mathrm{W}(x)\,dx + \mathrm{F}\frac{\{x-a\}^2}{2} - \mathrm{G}\{x-b\} \quad (17)$$

$$\mathrm{EI}\,y = \mathrm{EI}\,y_0 + \mathrm{EI}\,\theta_0 x + \mathrm{M}_0\frac{x^2}{2} - \mathrm{S}_0\frac{x^3}{6} + \int dx \int dx \int dx \int \mathrm{W}(x)\,dx + \mathrm{F}\frac{\{x-a\}^3}{6} - \mathrm{G}\frac{\{x-b\}^2}{2}. \quad (18)$$

Two of the constants S_0, M_0, θ_0 or y_0 will usually be fixed by the conditions of support at $x = 0$. Thus, for a simply supported end $y_0 = \mathrm{M}_0 = 0$, and for a built-in end, $y_0 = \theta_0 = 0$. The other two constants will be determined usually by the conditions of support at the other end of the beam.

With more than one concentrated load or couple, the single terms containing F or G will be replaced by sums of similar terms. In any specific case $\mathrm{W}(x)$ will be given and the integrations can be completed in each successive line. Thus, if there is uniform gravitational loading, $\mathrm{W}(x)$ will be a negative constant and the successive lines will contain successive powers of x; in the last line the term will be $-\dfrac{\mathrm{W}x^4}{24}$.

Throughout, the integrals may be regarded as definite integrals between 0 and x, or as indefinite integrals vanishing at $x = 0$.

The repeated integrals in equations (16), (17) and (18) may be reduced to single integrals by using the following result:

$$\frac{d}{dx}\int_0^x \mathrm{W}(\xi)\frac{(x-\xi)^{n+1}}{(n+1)!}\,d\xi = \frac{d}{dx}\int_0^l \mathrm{W}(\xi)\frac{\{x-\xi\}^{n+1}}{(n+1)!}\,d\xi$$

where l is the length of the beam, or any fixed upper limit greater than the values of x under consideration, since $\{x-\xi\}^{n+1}$ is zero in the extended part of the interval between $\xi = x$ and $\xi = l$, $x-\xi$ being there negative. Since the limits are now constant, the differentiation with respect to x may now be carried out under the sign of integration, giving

$$\frac{d}{dx}\int_0^x \mathrm{W}(\xi)\frac{(x-\xi)^{n+1}}{n+1!}\,d\xi = \int_0^l \mathrm{W}(\xi)\frac{\{x-\xi\}^n}{n!}\,d\xi = \int_0^x \mathrm{W}(\xi)\frac{(x-\xi)^n}{n!}\,d\xi.$$

Thus

$$\int_0^x \mathrm{W}(\xi)\frac{(x-\xi)^{n+1}}{(n+1)!}\,d\xi = \int dx \int_0^x \mathrm{W}(\xi)\frac{(x-\xi)^n}{n!}\,d\xi.$$

That is, $\int_0^x \mathrm{W}(\xi)\dfrac{(x-\xi)^{n+1}}{n+1!}\,d\xi$ is an indefinite integral of $\int_0^x \mathrm{W}(\xi)\dfrac{(x-\xi)^n}{n!}\,d\xi$ and it clearly vanishes at $x = 0$.

If the integral in equation (15) is written $\int_0^x \mathrm{W}(\xi)\,d\xi$, distinguishing the variable of integration from the upper limit, this is the same as $\int_0^x \mathrm{W}(\xi)\dfrac{(x-\xi)^0}{0!}\,d\xi$ which is of the form just considered with $n = 0$. The second integration which occurs in equation (16) is therefore given by $\int_0^x \mathrm{W}(\xi)\dfrac{(x-\xi)}{1!}\,d\xi$. This is of the same form again with $n = 1$, so that the next integration gives $\int_0^x \mathrm{W}(\xi)\dfrac{(x-\xi)^2}{2!}\,d\xi$ and the last, in the same way, gives $\int_0^x \mathrm{W}(\xi)\dfrac{(x-\xi)^3}{3!}\,d\xi$.

The set of equations (14) . . . (18) may therefore be re-written in the form

$$w = \mathrm{W}(x) + \mathrm{F}\,\delta(a) - \mathrm{G}\,\delta'(b) \quad (14a)$$

$$-\mathrm{S} = -\mathrm{S}_0 + \int_0^x \mathrm{W}(\xi)\,d\xi + \mathrm{F}\{x-a\}^0 - \mathrm{G}\,\delta(b) \quad (15a)$$

$$\mathrm{M} = \mathrm{M}_0 - \mathrm{S}_0 x + \int_0^x \mathrm{W}(\xi)(x-\xi)\,d\xi + \mathrm{F}\{x-a\} - \mathrm{G}\{x-b\}^0 \quad (16a)$$

$$EI\theta = EI\theta_0 + M_0 x - S_0 \frac{x^2}{2} + \int_0^x W(\xi) \frac{(x-\xi)^2}{2} d\xi + F \frac{\{x-a\}^2}{2} - G\{x-b\} \quad (17a)$$

$$EIy = EIy_0 + EI\theta_0 x + M_0 \frac{x^2}{2} - S_0 \frac{x^3}{6} + \int_0^x W(\xi) \frac{(x-\xi)^3}{6} d\xi + F \frac{\{x-a\}^3}{6} - G \frac{\{x-b\}^2}{2} \quad (18a)$$

It will be seen that the integrals now represent summations of the contributions from the elementary load $W(\xi)\,d\xi$ at the point ξ, the integrand having the same form as the concentrated-load term with F replaced by $W(\xi)\,d\xi$ and a by ξ. Equations (15*a*) and (16*a*) may be obtained directly in this form by resolving and taking moments about the end x, for the portion of the beam between 0 and x. Only loads between 0 and x contribute to these equations, a load $W(\xi)\,d\xi$ to the right of x being excluded by the upper limit of the integral. Every concentrated load F is however written down, those to the right of x being eliminated because the Macaulay power vanishes if $a > x$. In the same way every elementary load may be included if $(x - \xi)$ is replaced by $\{x - \xi\}$ and the integration is taken over the whole length of the beam.

We thus have another alternative form for the equations giving equations (14*b*) . . . (18*b*) of which only the last is written thus

$$EIy = EIy_0 + EI\theta_0 x + M_0 \frac{x^2}{2} - S_0 \frac{x^3}{6} + \int_0^l W(\xi) \frac{\{x-\xi\}^3}{6} d\xi + F \frac{\{x-a\}^3}{6} - G \frac{\{x-b\}^2}{2} \quad (18b)$$

In this form the earlier equations may be obtained by differentiation with respect to x, it being legitimate to differentiate under the integral sign since the limits are now constants. In a specific case of course the integrals would be evaluated so that no difficulties of this sort would arise.

REFERENCES

[1] "On the Bending of an Initially Straight Beam Under Arbitrary Loading," by A. W. Gillies, *Phil. Mag. Ser.* 7, page 813, vol. xxxvii (Dec., 1946).

The application of the author's method to a number of examples will be the subject of a second article in the near future.

★ ★ ★

PRE-SET BORING HEAD

The "Sizer" pre-set boring head, which has for some time been fitted to the boring machines made by Paddon Precision Tools, Limited, 26 Glenburnie-road, London, S.W.17, is now available as a separate item. There are three sizes covering the range of bores from 1⅛ in. to 6 in.

The outfit consists of three parts: the head itself; the cutting tool; and the setting micrometer. Setting up is quite simple; the micrometer jig is set to the required size (the instrument is direct reading) and the tool inserted. A spring-loaded plunger in the shank of the latter allows it to assume the correct size without the errors due to individual "feel." The plunger is then locked. Next, the tool is transferred to the boring head and inserted in the socket. A special cam-lock locates the tool against a hardened and ground pad within the boring head and locks it there.

It is stated that consistent sizing can be obtained within very close limits, and the size of the final hole is known without reference to any other measuring equipment. The head can be used in any boring, milling or drilling machine, or in a lathe. It can also be transferred from one machine to another without altering the setting.

CONTROLLED SUPERHEAT IN AN INTEGRAL FURNACE BOILER

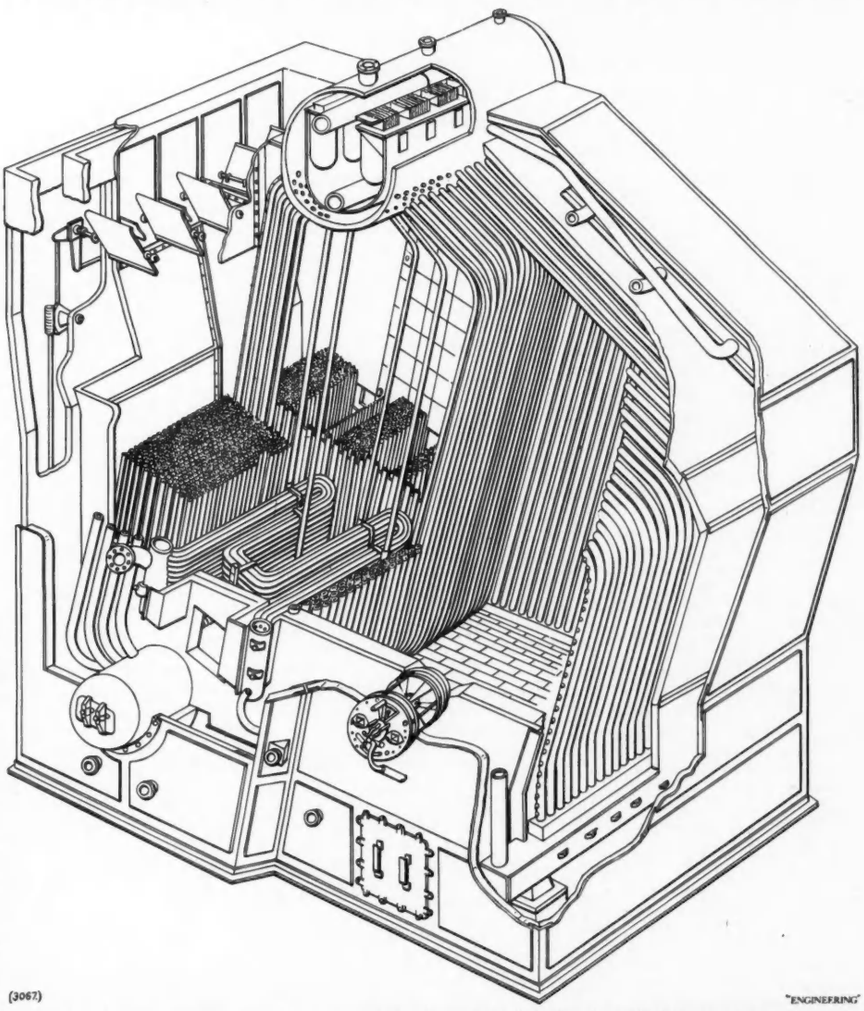
The ability to vary the final steam temperature from a boiler over a relatively wide range is becoming increasingly valuable as higher temperatures are used in marine work. In addition, there is a demand for saturated steam for ships' auxiliaries which boilers of conventional design cannot satisfy unless they incorporate a large and often inconvenient de-superheater. Boilers have previously been designed for wide variation of steam temperature, but they have generally been of the twin-furnace type, which are both expensive and bulky.

A boiler combining the advantages of twin-furnaces with the simple construction and relatively small bulk of the integral furnace has been made by Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4. It is called the "Selectable Superheat" marine boiler, and with it the steam temperature required can be selected and maintained over a wide range of load. Large quantities of near-saturated steam can be provided for cargo pumping and heating, Butterworth tank cleaning, or other auxiliary services, without endangering the superheater.

The general arrangement of the boiler is shown in the accompanying illustration, from which it will be seen that the gas flow from the furnace is split between two parallel passes, one containing banks of convection tubes and a superheater, the other convection tubes only. The two sections are separated by a stud-tube wall, which can be seen just behind the superheater. Control of the relative gas flow in either of these two sections is by two sets of coupled dampers in the uptakes, one set being open while the other is closed. By simple damper operation the proportion of gases in the "superheater" and "saturated" passes can be varied to give the required final steam temperature. After passing the dampers the gas streams combine to pass through an economiser, or an air-heater, or both, before being discharged through the uptakes to the funnel.

Apart from the variable steam temperature, which is a function of the damper position, the control and operation of the boiler is identical with a standard single-pass integral furnace boiler, and the furnace can be fitted with a simple form of combustion control. This can be extended to operate the dampers, giving automatic control of steam temperature at any predetermined figure.

For security reasons no performance figures can be given for the Selectable Superheat boiler, but it has been in operation for some time under the most exacting conditions. Besides the general principle of working described above, there are several other points of interest. The boiler incorporates Cyclone steam separators in the drum; the furnace is constructed of stud-



(3067) "ENGINEERING"

Gas flow from the furnace of the "Selectable Superheat" boiler is split between two passes one containing convection tubes and a superheater, the other convection tubes only. Control of gas flow is by the coupled dampers seen at the top of the boiler.

tubes and chrome ore, as is the wall separating the gas flow into the two passes mentioned above; the boiler has been designed for accessibility and there are two access doors in both the superheated and the saturated passes; the dampers are made of heat-resisting steel and are positioned in a low gas-temperature zone to give them long life and freedom from distortion and burning.

★ ★ ★

THREE-SPEED HAND DRILL

Now being distributed in this country by the Industrial Chain Supply Company, Limited, 625 Fulham-road, London, S.W.6, the Peugeot model 314 hand-operated breast-drill offers the user a choice of three speeds.

Three spindles project from the gearbox, and the crank handle is pressed on to the one required. The ratios of the three are 1 to 2·25, 1 to 5·63 and for high-speed work, 1 to 14·06. The lower two ratios are most useful for general work with mild-steel and the harder metals, while the high ratio, with which drilling speeds of 1,400 r.p.m. can be obtained, is suitable for the softer materials including aluminium, plastics and wood. The gearbox is totally enclosed and the gears run in an oil bath; ball bearings are used on all spindles.

Although light in construction, it weighs only 3½ lb., the drill is robust; after two falls from a height of 6 ft. on to a concrete floor, no damage was sustained. The three-jaw chuck has capacity for drills up to ½ in. in diameter; spare drills can be kept in the tubular handle. Both breast-plate and side-handle are adjustable. Overall length is 16 in.

★ ★ ★

LOADING OF HIGHWAY BRIDGES

Colloquium in Lisbon in June, 1956

A colloquium entitled "Loading of Highway Bridges" is to be held in connection with the Congress of the International Association for Bridge and Structural Engineering at Lisbon in June, 1956. The questions to be discussed are as follow:—

1. The use of statistical methods for assessing the most severe combination of vehicle loading on given lengths and widths of bridges, and of the calculation of tolerable risk factors.

2. Data regarding the permissible operation of heavy vehicles and special loads, the permitted spacing and/or restriction on their passage over bridges, and other characteristics of actual traffic. Notes on possible future developments are particularly required.

3. Current specifications for design loads, together with justifications of the clauses.

4. Permissible stresses and limiting deflections allowed in conjunction with specified design loadings, including combinations of loadings and effects, as, for example, snow, ice, wind and temperature. The use of ultimate load theories and the allowances made for fatigue will also be discussed on this question.

5. Suggestions for modifying the specified loadings and permitted stresses will be discussed as a separate item.

6. Methods of assessing the load capacity of existing bridges.

The work of the British Group attending the colloquium will be dealt with by a small sub-committee consisting of Mr. C. S. Chettoe (chairman), Mr. H. C. Adams, Mr. O. A. Kerensky and Mr. A. W. Hill (secretary). Contributions, which should be sent not later than September 15 next, should be addressed to Mr. Hill, care of the Cement and Concrete Association, 52 Grosvenor-gardens, London, S.W.1. It is intended that official contributions will be made by the British group on questions 2, 3, 4 and 6, although individual contributions on questions 1 and 5 will be welcomed and forwarded to be considered for submission.

AVOIDING TEMPERATURE SHOCKS IN STEAM TURBINES

"SUPERHEAT BOOST" REDUCES RE-START TIME

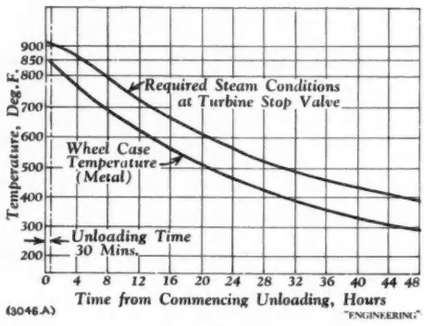


Fig. 1 Curves showing wheel case temperature and required steam temperature at turbine stop valve plotted against time from commencing unloading; inlet steam temperature was 900 deg. F.

One of the major problems of two-shift operation of large turbo-generator sets which run at high temperatures, is that when the turbines have to be re-started they are still at a high temperature, although the temperature of the steam from the superheaters will have fallen considerably as the boilers have been under reduced load. Severe temperature shocks are therefore liable to occur when commissioning the turbine following periods of two-shift operation or short-term shut-down of from 15 minutes to about 18 hours. These severe shocks must be avoided if reliability of operation and availability are to be maintained.

The difficulties involved in avoiding these temperature shocks will be appreciated from the graph in Fig. 1. This illustrates the cooling conditions of a set operating on inlet steam conditions of 900 deg. F., giving the actual wheel-case temperature of the turbine against times of commencing unloading, together with the required steam temperature should the turbine be recommissioned after a specific period of shut-down. The graph is based upon an unloading time of 30 minutes; a different unloading time would slightly affect the two curves.

Several means of eliminating temperature shocks due to this cause have been tried, for example, high-level burners, dump condensers, etc., but these methods have only been partially successful and have involved considerable wastage of water and heat. The control operations with these methods have been delicate and of relatively long duration.

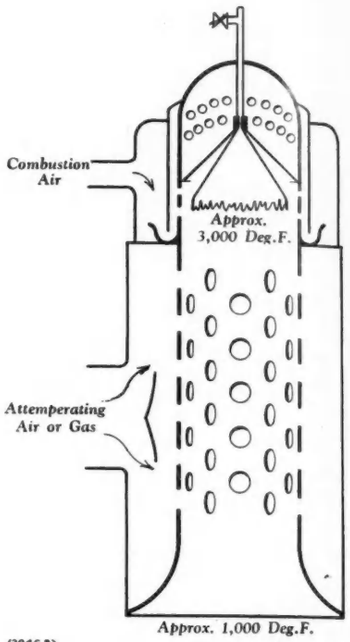


Fig. 2 A burner used in the combustors; combustion of the oil is complete in a distance of from 12 to 24 in. from the burner nozzle, according to the size of burner. Attemperating air or inert gas brings the hot gases down to the required temperature.

A system of superheat boost has been evolved by John Thompson Water Tube Boilers, Limited, Ettingshall, Wolverhampton, which employs hot gases derived from burning oil fuel in special gas-turbine burners or "combustors". Trials have been carried out at the John Thompson experimental station, and the system is to be used in the first two of eight 550,000 lb. per hour Thompson boilers in the Central Electricity Authority's Marchwood generating station. The system will also be used in the first three of six

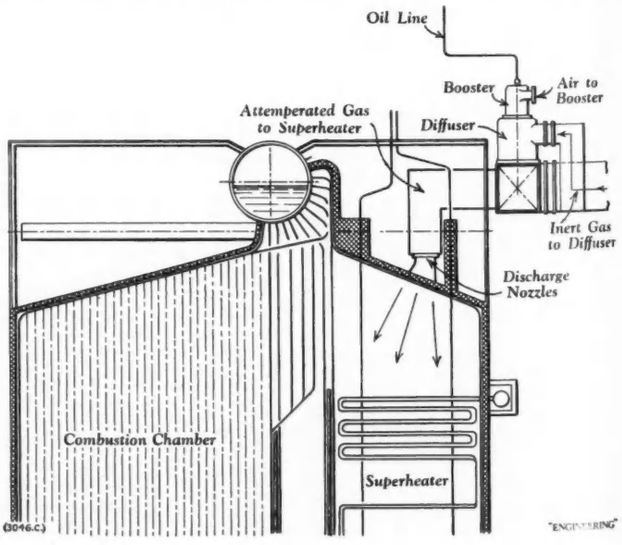


Fig. 3 Typical application of combustors to a boiler. The number and sizes of the combustors can be arranged to suit a particular installation.

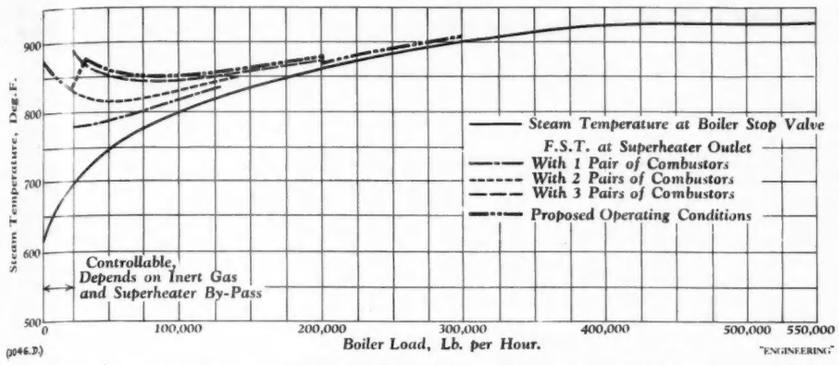


Fig. 4 Steam temperature at superheater outlet and boiler stop valve after 6- to 7-hour shut-down plotted against the boiler load. By bringing in the combustors gradually the steam temperature can be kept high enough to avoid temperature shock.

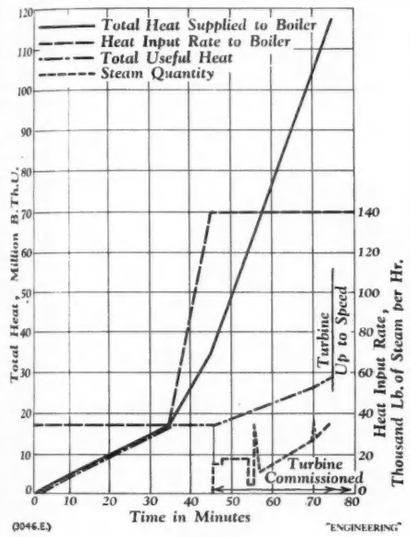

Total Heat Supplied to Boiler
Heat Input Rate to Boiler
Total Useful Heat
Steam Quantity
Total Heat, Million B.Th.U.
Heat Input Rate, Thousand Lb. of Steam per Hr.
Turbine Up to Speed
Turbine Commissioned
Time in Minutes
0 10 20 30 40 50 60 70 80
(0046.E)
"ENGINEERING"

Fig. 5

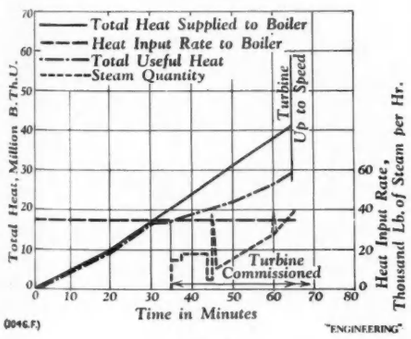

Total Heat Supplied to Boiler
Heat Input Rate to Boiler
Total Useful Heat
Steam Quantity
Total Heat, Million B.Th.U.
Heat Input Rate, Thousand Lb. of Steam per Hr.
Turbine Up to Speed
Turbine Commissioned
Time in Minutes
0 10 20 30 40 50 60 70 80
(0046.F)
"ENGINEERING"

Fig. 6

Figs. 5 and 6 Both graphs show the heat supplied to the boiler and the total useful heat available in the commissioning of a turbo-generator after 6 hours overnight shut-down. Fig. 5 shows normal commissioning, and Fig. 6 shows the effect of using combustors.

575,000 lb. per hour boilers in the Tilbury generating station.

ATTEMPERATING GASES IN THE COMBUSTORS

Fig. 2 illustrates diagrammatically the form of the burners used in the combustors. Combustion takes place in a small external combustion chamber and results in an intense white flame at a gas temperature in the region of 3,000 to 3,200 deg. F. Combustion of the oil is complete in a relatively short distance (12 to 24 in., depending on the size of the burner), and the resultant high-temperature gases are attemperated in the diffuser of the combustor by diluting with air or inert gas to reduce the temperature to the required level.

Since combustion is completed in the can of the burner itself, from the burner onwards there is no luminosity in the gases. A small amount of direct radiation from the can burner flame will pass through the outlet, but by arranging right-angle bends before the gases are supplied to the superheater this small amount of direct radiation is eliminated.

Fig. 3 shows a typical application of combustors to a boiler. The number of combustors arranged across the roof of the unit will be sufficient to ensure uniform gas temperature distribution to the superheater. The size of the combustors and their number can be arranged to suit the requirements of any particular installation. The system has the advantages of a separately-fired superheater, but avoids its disadvantages, such as direct radiation on the superheater and possible maldistribution of gas and steam.

Gas temperature of the non-luminous gases to the superheater can be controlled at such a value that it is not in excess of the permitted metal temperature of the tubes under full-load operation. Steam temperature from the superheater can therefore be a maximum yet complete safety can be ensured.

The steam temperature under these conditions may well be even higher than required at the turbine, but as considerable cooling is to be expected in the associated steam pipes, this represents a further advantage. In most practical cases the control of the combustors will be decided by the temperature at the turbine throttle valve, to ensure that the pipelines have been adequately heated.

The improvement which can be affected in the steam temperature by using superheat boost is indicated in the graph, Fig. 4. This illustrates the steam temperature characteristic at 900 lb. per square inch for a 60-MW unit. The characteristic may, however, be considered as typical for larger or smaller units. It will be seen from this curve that at the loads required for commissioning and running the turbines up to speed, the steam temperature from the unit under ordinary conditions of operation is very little above saturation temperature. To maintain the required conditions with superheat boost, the combustors are operated and switched off in sequence; the affect of this operation is shown in the graph.

FUEL CONSUMPTION WITH AND WITHOUT COMBUSTORS

The considerable reduction in waste water and heat which can be achieved by the use of the Thompson superheat boost system is also significant. Two comparable graphs, Figs. 5 and 6, illustrate this point.

The graph in Fig. 5 indicates the normal time and conditions for commissioning a turbine after an over-night shut-down of six hours. These data apply generally whether oil or pulverised-fuel firing is employed. The initial 35 minutes are employed in re-establishing boiler pressure lost during the shut-down, when the pressure has fallen from about 900 lb. per square inch to about 500 lb. per square inch. From then onwards the heat input to the boiler will be that necessary to commission the turbine, heat the pipework, etc. To ensure a satisfactory steam temperature for the turbine, the steam flow needs to be some 140,000 lb. per hour, i.e., approximately 25 per cent. full load. During the whole of the time of commissioning up to the point when the load carried on the set requires 140,000 lb. of steam, the surplus steam must be dumped, a serious waste which at the same time involves careful operating technique.

In Fig. 6, substantially similar data are shown when commissioning the same unit after a six-hour overnight shut-down, but in this case employing superheat boost. The same interval (35 minutes) is required to recover the boiler pressure but by this time it is possible to commission the turbine immediately. The normal burners are employed to provide the heat necessary to recover the pressure, and the superheat boost burners are fired at the same time to heat up the superheater and provide the required steam temperature. Using combustors, the steam heat input rate may be maintained as during the pressure rise (equivalent to 35,000 lb. per hour), but immediately the turbine is commissioned all the steam may be used for power generation. The only steam which will be wasted during commissioning of the turbine when using combustors is that represented by the difference between a constant heat equivalent of 35,000 lb. per hour and the actual curve showing the turbine requirements, and some of this will be used for warming drains and similar functions.

On this basis, the saving achieved by the use of superheat boost on a typical 60-MW set would be about 4½ tons of coal per start. If the plant were started 120 times in a year the annual saving would be more than £2,000.

★ ★ ★

A NEW HOUSE JOURNAL

Machine Tool Practice

Production News, the house journal of Drummond-Asquith (Sales), Limited, King Edward House, New Street, Birmingham, 2, first appeared earlier this year, and has now run to its second number. Published quarterly, the journal is the successor to the *Radial Times*, which was issued by William Asquith, Limited, Halifax, regularly for seven years until the outbreak of war. The new journal covers a wider field, taking in the activities of William Asquith, Limited, Drummond-Asquith (Sales), Limited, Drummond Brothers, Limited, Guildford, Modern Foundries, Limited, Halifax, and R. Woodvine and Sons, Limited, Shrewsbury. Between them the associated companies manufacture, or are agents for, a large range of machine tools and allied equipment, and the journal is devoted to illustrated articles on their design and use.

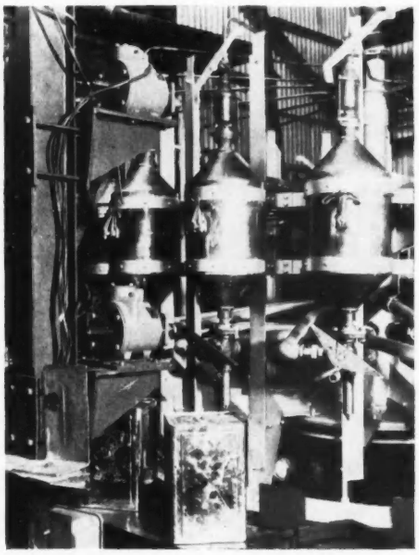
Both standard and special machines are dealt with in the two issues so far published. Included in the first issue, for example, are articles on a special Asquith horizontal boring machine for Diesel-engine cylinder liners, the "Maxicut" electronic copying lathe and the Waldrich "thread peeler" or "whirler" for the high-speed production of long screws, which combines the principles of both turning and thread milling. In the second issue the equipment described includes a composite group of machine tools installed at the Rugby works of the British Thomson-Houston Company, multi-tool lathes for rear-axle casing production, and Dawson cleaning and degreasing machines.

A high standard of production has been set in the first two issues of the journal, and it is well illustrated, both pictorially and with reproductions of drawings when necessary. With such a large range of tools and equipment to cover, there would appear to be ample scope for future issues of the journal.

AUTOMATIC CAN-FILLING MACHINE

HIGH-SPEED OPERATION CONTROLLED PHOTO-ELECTRICALLY

A fully-automatic rotary kerosine can-filling machine to the Burmah Oil Company's design and requirements has been produced by Watts Fincham, Limited, 9 St. Helen's-place, London, E.C.3, and built by Hubbard Brothers, Limited, Basingstoke, Hampshire. The machine, which will fill four-gallon tins at a rate of over 1,200 per hour, incorporates a variable-speed mechanism and a photo-electric control system. It is believed to be the first of its type to be made in this country and will be installed in a tin factory in Chittagong. Part of the machine showing in particular, the photo-electric control system, which was supplied by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, is shown in the illustration.



Interruption of the light beam from the source at the right of the tin energises the solenoids mounted on the upright stanchion, which, in turn, operate the valves of the volumetric measures.

Standard square tins having a capacity of four imperial gallons are used. The empty tins, which are transported to the machine by conveyor, are fed on to the rotating circular table in such a way that each tin is accurately positioned immediately beneath a non-ferrous filling nozzle. There are eighteen nozzles connected through valves to volumetric measures which can be adjusted to suit the specific gravity and temperature of the liquid to be filled.

Kerosine from the service tank, located approximately 8 ft. above the level of the machine, passes through a central feed pipe connected by means of a mechanical seal to the rotating reservoir of the machine, and is then conducted by 18 branch pipes through control valves to the base of the volumetric measuring units. The input of kerosine to these measuring units is controlled by a float-operated cut-off valve, which is connected to its fellow on the opposite side of the machine by an air balance tube. Venting to atmosphere, if necessary, is arranged by means of a small three-way valve situated on top of the cut-off valve.

OPERATION AND CONTROL

As the circular table rotates, the lever of the control valve situated at the base of the measure encounters the projecting plunger of a solenoid if there is a tin in position beneath the filling nozzle. Should there be no tin in this position the plunger of the solenoid is retracted and the valve is not operated. The solenoid, which is the lower of the two attached to the column in the illustration opens the control valve mentioned above, and this allows the kerosine to pass from the volumetric measure into the tin below. At the same time the control valve at the bottom of the associated measure on the other side of the machine encounters a fixed stop which closes the control valve and allows the measure to fill. The purpose of the air balance pipe is to ensure that the influence of the gravity head from the service tank is used both for filling each measure and for emptying its opposite number, thereby making it possible to attain a high rate of operation.

The photo-electric control system ensures that, even at the high rates of operation attained, the measures will not be discharged if there is no tin in position beneath the filling nozzle. A light projector, which can be seen to the right of the kerosine tin in the foreground is aligned on the photo-cell in the left foreground. The tins which are positioned on the circular table cut off the light beam, the lower solenoid controlling the opening of the control valve for filling the tin is not energised, and the plunger accordingly remains in a projected position and actuates the valve lever. The upper solenoid, however, which controls the venting of the air-balance pipe, is energised and its plunger is retracted so that it does not protrude and operate the lever on the vent valve. If, however, there is a break in the supply of tins, the light beam operates the photo-cell, the actions of the two solenoids are reversed and the filled measure will not be discharged. Its fellow measure on the far side of the machine will still be filled, the air displaced during filling being vented by the means already described above to atmosphere. This system enables the machine to operate automatically at high speed without spillage of oil.

★ ★ ★

MULTI-PURPOSE WOOD-WORKING MACHINE

Spindle Moulder with Single-lever Control

The new spindle moulder introduced by Thomas Robinson and Son, Limited, Railway Works, Rochdale, Lancashire, is adaptable to a variety of woodworking jobs, and is controlled by a single lever at the front of the machine. From this position the operator can start and stop the machine, apply the spindle brake, and lock the spindle when cutters are to be changed. If necessary, the operator can bring the spindle to rest by moving the lever with his knee. The work can thus continue to be held with both hands while the machine is stopped. The lever operates through a gated panel, which is clearly marked "run," "stop," "neutral," "brake," and "lock." Only one gate can be entered at any one time, and the drive-motor start and stop buttons are operated mechanically by the control lever. The motor cannot be started when the lever is in any position other than that marked "run."

The cutter spindle is carried in ball bearings mounted in a cast-iron housing, which is designed to allow the operator to stand close to the work. A 4-h.p. electric motor, totally enclosed and with a removable cover, drives the spindle by means of a pulley and an endless, flat, leather and plastic sandwich belt. The driving pulley on the motor is of the two-step cone type, to give two spindle speeds. Automatic adjustment of the belt tension according to the load is provided by the design of the motor mounting. The cutter spindle, which is normally of the heavy-duty type, with a detachable top section 1¼ in. diameter to carry the cutter-block, runs at either 4,100 or 6,500 r.p.m. when the current supply has a periodicity of 50 cycles, and 4,950 or 7,900 r.p.m. with 60-cycle current. As an alternative a light-duty spindle can be provided; the detachable top section is then ¾ in. diameter and the speeds are 5,300 and 8,500 r.p.m. with a 50-cycle supply and 6,450 and 10,300 r.p.m. with 60 cycles. Rotation is in one direction only on the standard machine, but a reversible spindle can also be provided when specially ordered.

QUICKLY-REMOVABLE TOP SECTIONS

Both the heavy-duty and the light-duty spindle are of the same type. They have quickly-detachable top sections, and several of these can be kept fitted with cutter-blocks and cutters ready for mounting in the spindle as required. The detachable top sections have parallel shanks and are held securely in the main spindle by a cotter, locating collar and locknut. To remove the top section it is only necessary to slacken the locknut, raise the locating collar and withdraw the cotter. The spindle top can then be lifted out. When it is locked in its working position it has the complete rigidity necessary for high-speed operation. Vertical adjustment of the spindle is controlled by a handwheel at the side of the machine; one complete revolution of the handwheel raises or lowers the spindle ⅛ in.

The standard table has a series of tapped holes for the fence, but a slotted table is also available as an alternative. Machined clamping ledges are provided on the left and right under-

Only one control, a single-gated lever at the front of the machine, is used on the Robinson spindle moulder. It can do a wide range of machining operations on wood.

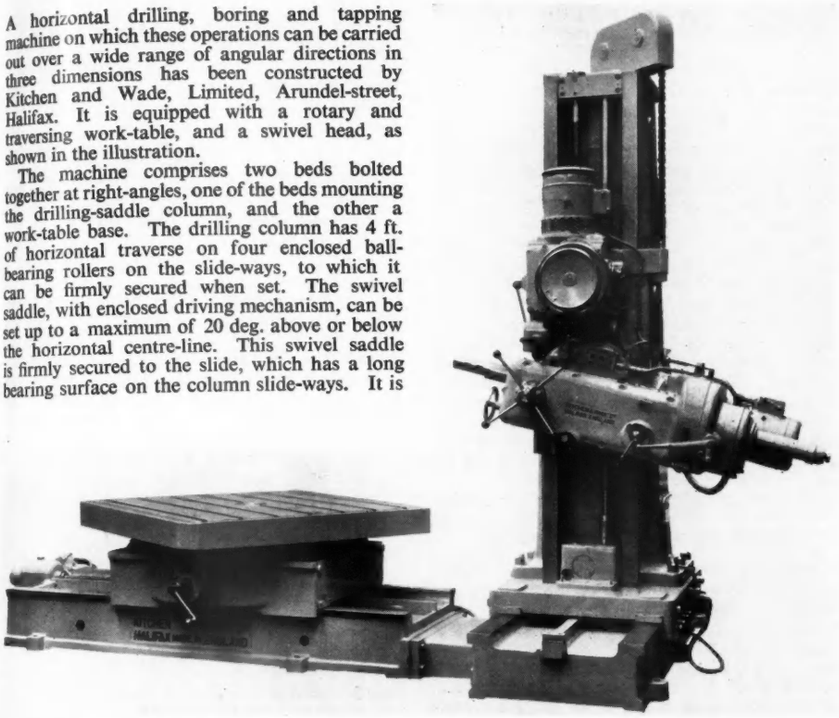
side edges of the table. The edges are planed square and parallel for the use of jigs and "G" clamps. A set of concentric table rings, to suit various diameters of cutter, is included. Any of these rings can be turned over so that the reverse side, which has a flange, can be used as a guide ring. Each half of the fence can be adjusted relative to the other by a screw, and locked by a handwheel, or if required the complete fence can be adjusted or removed as a single unit. Adjustments are by hand, no tools being needed. A combined guard and exhaust hood, with a vertically-adjustable front window is available as an optional extra fitting. A variety of attachments for such operations as dovetailing, corner-locking, tenoning and stair-stringing can be provided, the actual operations which the machine can be adapted to perform depending upon whether the spindle is of the light-duty or the heavy-duty type.

DRILLING AND BORING FROM ALL ANGLES

MACHINE WITH 30-500 R.P.M. SPINDLE SPEEDS

A horizontal drilling, boring and tapping machine on which these operations can be carried out over a wide range of angular directions in three dimensions has been constructed by Kitchen and Wade, Limited, Arundel-street, Halifax. It is equipped with a rotary and traversing work-table, and a swivel head, as shown in the illustration.

The machine comprises two beds bolted together at right-angles, one of the beds mounting the drilling-saddle column, and the other a work-table base. The drilling column has 4 ft. of horizontal traverse on four enclosed ball-bearing rollers on the slide-ways, to which it can be firmly secured when set. The swivel saddle, with enclosed driving mechanism, can be set up to a maximum of 20 deg. above or below the horizontal centre-line. This swivel saddle is firmly secured to the slide, which has a long bearing surface on the column slide-ways. It is balanced by a weight housed inside the column, and locking motions are provided for the saddle and column movements. The drilling head has a vertical traverse of 4 ft. on the column.



A new machine for drilling, boring and tapping from almost any angle, with facilities for adjusting the relative position of work-piece and tool in three dimensions.

The splined spindle has a minimum diameter of 2 in., and at the nose it is bored No. 5 Morse taper. It is supported throughout its 18-in. traverse by a large-diameter steel sleeve, on which the feed rack is cut. Both fine and rapid hand adjustments are provided to the spindle, the former by the small hand-wheel at the side and the latter by the cross-handles. Once the desired position has been reached, the slide-forward push on the cross-handles engages the power feed. The cross-handles also permit sensitive lever feed when drilling small-diameter holes.

AUTOMATIC FEEDS

There are three rates of automatic feed to the spindle, ranging from 80 to 120 cuts per inch. A 5-h.p. motor and starter are built in, and six changes of spindle speed from 30 to 500 r.p.m. are available. The driving gears are of hardened nickel-chromium steel, carried on ball-bearing mounted shafts of high-tensile steel. Power rapid traverses are provided for the saddle vertical movement and column horizontal movement, and hand-wheels are fitted for fine adjustments to these motions.

A built-in oil pump supplies lubricating oil to the saddle mechanism, and a visual indicator is mounted on the front of the saddle. The T-slotted work-table is 5 ft. square and has a power traverse of 4 ft. towards and away from the spindle, controlled from the saddle. A jacking motion facilitates the rotation of the table, which can be quickly locked by plunger in any of the four 90-deg. positions. The table is graduated over 360 deg. and may be set at any angular position.

LAUNCHES AND TRIAL TRIPS

M.S. "RED GAUNTLET."—Single-screw trawler, built by John Lewis and Sons, Ltd., Aberdeen, for the Iago Steam Trawler Co., Ltd., Fleetwood, Lancashire. Main dimensions: 135 ft. between perpendiculars by 26 ft. 6 in. by 13 ft. 3 in.; fishroom capacity, about 9,300 cub. ft. Five-cylinder Diesel engine developing 800 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Trial trip, July 4.

S.S. "WORLD SINCERITY."—Single-screw oil tanker, built by Kockums Mekaniska Verkstads A/B., Malmö, Sweden, for Mr. Stavros S. Niarchos, New York. Main dimensions: 662 ft. 5 in. overall by 86 ft. by 46 ft. 3 in.; deadweight capacity, about 32,500 tons on a draught of 34 ft. 5 in. Largest vessel constructed by these builders. Steam-turbine propelling machinery developing 16,500 b.h.p., constructed by Akt. De Lavals Angturbin, Stockholm, Sweden. Speed, 17 knots. Launch, July 6.

M.S. "OREDIAN."—Single-screw ore-carrying vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, Durham, for Ore Carriers, Ltd., London, E.C.3. Fourth vessel of an order for six. Main dimensions: 407 ft. between perpendiculars by 57 ft. by 33 ft. 4 in.; deadweight capacity, 9,075 tons on a draught of 25 ft. 6 in. Two Gray-Polar five-cylinder Diesel engines coupled to one propelling shaft through Vulcan hydraulic clutches and reduction gearing supplied by David Brown and Sons (Huddersfield), Ltd., Huddersfield. Service speed, 12 knots. Trial trip, July 22.

M.S. "WARRINGA."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Tasmania to Australia trade of Huddart Parker, Ltd., Melbourne. Main dimensions: 320 ft. between perpendiculars by 49 ft. 6 in. by 29 ft. 8 in. to shelter deck; deadweight capacity, 4,280 tons. Ailsa-Doxford four-cylinder opposed-piston Diesel engine, developing 2,000 b.h.p. and installed by the shipbuilders. Trial trip, July 27.

H.M.S. "DUFTON."—Twin-screw coastal mine-sweeper, built by the Goole Shipbuilding and Repairing Co. Ltd., Goole, for the Admiralty, London, S.W.1. Main dimensions: 140 ft. by 28 ft. by 14 ft. 9 in.; armament, three small guns. Diesel propelling engines supplied by Mirrlees, Bickerton and Day, Ltd., Stockport. Trial trip, July 28.

M.S. "DOLIUS."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for Alfred Holt & Co., Liverpool. Main dimensions: 452 ft. 9 in. between perpendiculars by 62 ft. by 35 ft. 3 in.; gross tonnage, about 7,800. Harland-B. and W. six-cylinder single-acting two-stroke opposed-piston oil engine. Launch, August 4.

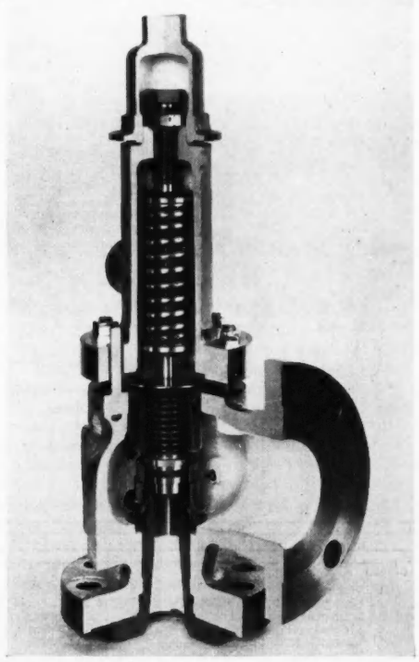
M.S. "FOYLEBANK."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for the Andrew Weir Shipping and Trading Co., Ltd., London, E.C.3. Fifth vessel of a series of six for these owners. A further series of six cargo-carrying vessels, of a larger type, are to be constructed at Belfast for the same firm. Main dimensions: 425 ft. between perpendiculars by 59 ft. by 38 ft. 3 in. to shelter deck; gross tonnage, 5,671. Harland-B. and W. six-cylinder single-acting two-stroke opposed-piston Diesel engine. Trial Trip, August 4.

★ ★ ★

PRESSURE-BALANCED RELIEF VALVE

A new addition to the range of valves made by the Crosby Valve and Engineering Company, Limited, Ealing-road, Wembley, Middlesex, is the "Protecto-seal" relief valve, which is designed to operate regardless of changes of pressure on the downstream side. A part section is shown in the illustration.

As in some other models, the pressure balance is achieved by the use of a stainless-steel bellows which has an effective area equal to that of the nozzle and disc seat. This bellows forms a seal between the body of the valve and the bonnet, or spring case, and is very liable to damage through vibrations set up during discharge. In the Protecto-seal, however, the bellows is protected by a surrounding shield which is so arranged that when the valve lifts, the top of the seating disc bears against the end of the shield and so seals off the bellows. This action also prevents any fluid reaching the guide and spring, and so prevents any possibility of escape to atmosphere. The new relief valve is interchangeable with the present JO-35 range.



Shielded stainless-steel bellows permit the relief valve to operate at the same pressure irrespective of changes of pressure on the downstream side.

SAFETY ON THE RAILWAYS

DRIVER'S VIGILANCE AUTOMATICALLY CHECKED

A system for the safety control of all types of locomotives has been developed by the Oerlikon Engineering Company of Switzerland, and is manufactured under licence by Davies and Metcalfe Limited, Romiley, Manchester. The system consists of a device which, after the train has covered a certain distance, operates a warning signal and subsequently the train brakes. The device can be reset before the brakes are applied, and resetting can be done manually by the driver or automatically when the driver operates certain controls. Thus while the driver is busy operating the controls he is not bothered by having to reset the safety device. At the same time, it ensures that during periods of inactivity if he remains unconscious or goes to sleep for longer than it takes to cover the pre-set distance the train will come to a halt. It will operate even if he inadvertently keeps the safety pedal depressed.

Safety control devices are designed to switch off the traction motor if the driver becomes unfit and to apply the train brakes. Train control by lineside devices ensures that on over-running a signal at danger the train will automatically be stopped, but it is still important that the train should be stopped independently of the signals if the driver becomes disabled. There have been innumerable suggestions and patents relating to safety devices; the only two mentioned here are those most commonly used in Switzerland, where the development work on the device to be described was carried out. They are the time-interval safety control and the space-interval safety control. Both start to operate when the driver releases a pedal or push-button switch which normally has to be kept pressed down during a run. The traction motors are then switched off and the brake applied, the first after the lapse of a predetermined time and the second after a certain distance has been covered. With the time-interval system the lapse of time is always the same and is independent of the speed; when the train is standing the device must be cut out if the driver leaves the pedal, and this is usually done by setting the handle of the reversing switch back to the neutral position. The space-interval system does not operate at standstill, because the apparatus is driven from an axle. The time-lag of the emergency brake is common to both systems; the driver can leave the pedal, move about the cab for a short while and return to press the pedal when or before a buzzer gives its warning.

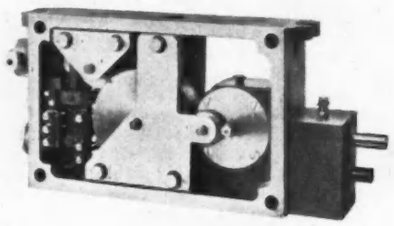
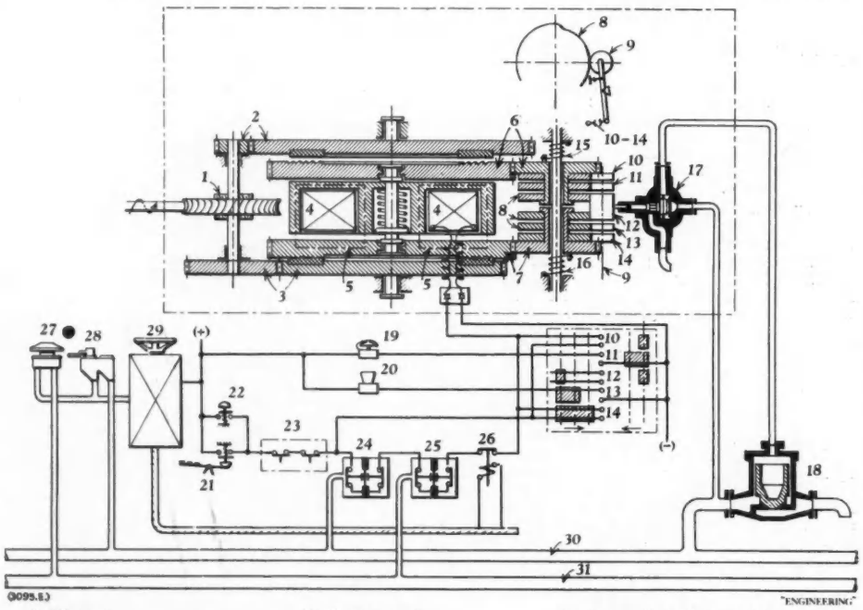


Fig. 1 View of the opposite side of the safety apparatus illustrated in Fig. 3, showing the side with the 1·25 miles run-down travel. Comparison of Figs. 1 and 3 shows the two different gear ratios.

UNOBTRUSIVE SUPERVISION

There are three main causes which may disable a driver, namely, unconsciousness, sleep, and diversion. All safety devices are designed to operate if the driver becomes unconscious, although some may not be effective in every case. On the other hand, there are not many devices which act satisfactorily if the driver falls asleep, because in many cases he will remain pressing the pedal or push-button. Only if the effort required to keep the pedal or push-button depressed is considerable will it infallibly operate when the driver falls asleep. Then the effort in keeping the switch depressed will cause the driver to become fatigued, and partly defeat the object of the safety device. There is also the possibility that the safety pedal may become blocked or wedged, and the driver's unfitness will not be communicated to the safety system.



1	Worm gear	15, 16	Re-set springs	24	Pressure-fluctuation switch for automatic brake
2	Spur gear with large reduction ratio	17	Control valve	25	Pressure-fluctuation switch for direct brake
3	Spur gear with small reduction ratio	18	Brake valve	26	Auxiliary relay for master controller
4	Magnet coil of coupling	19	Warning bell	27	Direct brake valve
5	Magnetic circuit of 4	20	Buzzer	28	Driver's brake valve for automatic brake
6, 7	Spur gears	21	Pedal contact	29	Master controller
8	Cams	22	Push-button	30	Main piping of automatic brake
9	Rollers	23	Apparatus for the automatic train safety control	31	Main piping of direct brake
10-14	Contacts				

Fig. 4 A diagram showing the mechanical and electrical circuits of the safety device.

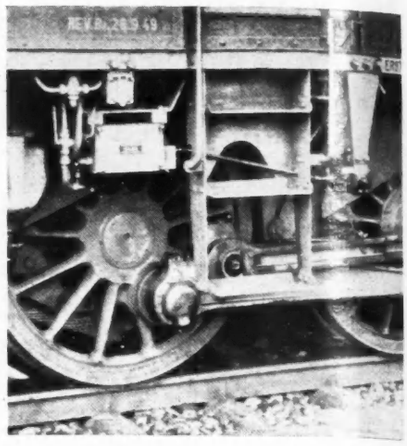


Fig. 2 Safety apparatus of the space-interval type. The apparatus is driven by the connecting rod on the right through a fork, a bell-crank drive and a Cardan shaft. It can also be driven directly from an axle.

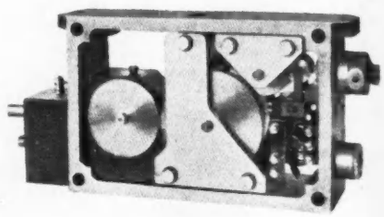


Fig. 3 Interior view of the space-interval safety apparatus, showing the side with the 328 ft. run-down travel. On the left, the driving shaft; upper right, the control valve; lower right, the union for the control piping.

The system designed by the Oerlikon Engineering Company makes use of the fact that every manipulation of the engine controls by the driver shows that he is alert, and can therefore be used to reset the safety device. In this way the drive, as long as he manipulates a driving control within a definite time interval or space interval, is totally unaware of any supervision although it is constantly present. But when during the journey he is not obliged to manipulate any controls for a long period, as, for example, on a long mountain run, the warning signal will be given, so that he has consciously to reset the safety apparatus. This small strain can well be expected of the driver in view of the enhanced safety during the whole journey. The more strain on the driver due to manipulation of the controls, the less strain there is due to the effort of controlling the safety apparatus.

The system was tried out on the Swiss Federal Railways using both time-interval and space-interval devices. It was found that the space-interval equipment, which is shown in Figs. 1, 2 and 3, and diagrammatically in Fig. 4, was more satisfactory because it worked only when the vehicle was moving. The results of the tests were good, and the Swiss Federal Railways decided to fit all new traction vehicles with this safety control.

CONSCIOUS AND UNCONSCIOUS OPERATION

The method of operation of the system can be seen from Fig. 4. The drive to the safety apparatus is taken from one of the axles through a worm gear 1 and two sets of spur gears 2 or 3,

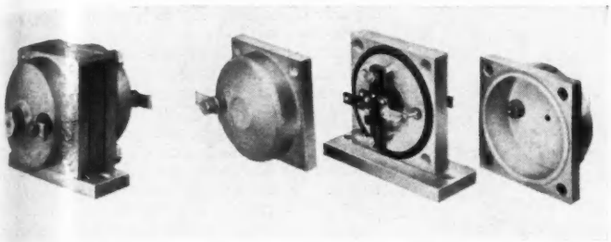


Fig. 5 Pressure-fluctuation switch. The complete switch is on the left and the view of a switch opened shows the diaphragm and controls.

with different gear ratios. An electro-magnetic coupling with coil 4 and magnetic circuit 5 permits the coupling of two further gears 6 or 7 with the driven of the gears 2 or 3. With the coil excited, the gears 2 and 6 are coupled together and with the coil unexcited the gears 3 and 7. The driven gears 6 or 7 rotate interchangeable cams 8 which operate the contacts 10–14 over rollers 9. The cams 8 are returned to their position of rest by means of the re-set springs 15 or 16 with the gears 6 or 7 disengaged. The further rotation of the cams beyond their position of release is prevented by gaps between teeth or friction couplings in the pairs of gears 6 and 7. The release system consists of the contact 12 and the control valve 17 which sets the pneumatic brake in action through an outlet valve 18. This release system is operated by two cams coupled to the gear 6 or 7. Shortly before release a signal is made to the driver either by a bell 19 or by the buzzer 20 of the existing safety control, through the cam-operated contacts 11 or 13. He thus still has the possibility of preventing or restoring the release. The remaining contacts 10 and 14 ensure the correct working of the apparatus under special service conditions.

In service the safety apparatus works as follows. With the pedal 21 or the push-button 22 pressed down and the contacts of the apparatus 23, 24, 25, 26 closed the magnet coil 4 is excited, the gears 2 and 6 are coupled, and the release is effected after running over a length of route S_1 determined by the gear ratios and the shape of the cams. When the pedal contact 21 and the push-button 22 are open the gear 3 is coupled to 7, and the release follows after a shorter length of travel S_2 as the gears 3 have rather lower ratio than gears 2. The length of travel S_3 corresponds to that of the safety apparatus used hitherto and is 328 ft.; a suitable distance for S_1 over the routes where the device was tested was found to be 1·12 to 1·25 miles. Within this length of travel the driver mostly operates the controller or the driver's brake valve at least once, and thus unconsciously he resets the safety control and the bell 19 only occasionally rings. From tests on the Swiss Federal Railways' locomotive No. 14315 it was shown that with mixed goods traffic in the mountains as well as in level country this only happens on the average every 12·43 miles. For passenger or fast trains a still higher average may be expected.

When the bell rings the driver can reset the apparatus in a number of ways: by short-time release of the safety pedal; operation of the master controller; operation of the driver's brake valve of the automatic brake; operation of the direct brake valve.

PRESSURE-FLUCTUATION SWITCHES

For the unconscious resetting of the safety device there are three switches 24, 25, 26, the opening contacts of which are in the circuit the magnet coil 4 of the safety apparatus. The contact of the apparatus 26 opens for a short time when the controller or the step-switch of the locomotive is moved from one step to another. The pressure-fluctuation switches 24 and 25 open their contacts temporarily when pressure fluctuations occur in the air pipes to the brakes, i.e., when the driver operates a driver's brake valve. For this purpose an apparatus, shown in Fig. 5, was developed which responds throughout the pressure range to the smallest pressure fluctuation (down to 0·75 lb. per square inch). It contains two air chambers which are separated by a diaphragm, one of which is connected to the main pipe of the automatic brake 30 and the other to the main pipe of the direct brake 31. This diaphragm deflects when there is a pressure difference and so opens a contact. Through a small hole in the dividing wall of the two chambers the pressure difference is equalised between them and with it the reclosure of the contact is effected when there are stationary pressure conditions in the brake pipes.

Fig. 6 shows part of a run-down diagram of the safety apparatus, with the run-down of the safety apparatus in locomotive miles plotted against the route miles travelled. The horizontal lines I, II and III show respectively: at 1·118 the warning signal sounds (I); at 1·213 miles the traction motors are switched off (II); at 1·254 miles emergency braking starts (III). Reading along the base line, the driver has to operate various controls until he reaches 221·2 miles, and the apparatus is always reset before the bell rings. For 1·118 miles after this point he manipulates no controls, and the bell rings. He resets the apparatus, and again nothing happens until 223·209 miles, when he is taken ill. At 223·452 miles the bell sounds, but the apparatus is not reset. At 223·558 miles the traction motors are switched off, and at 223·591 miles the emergency brakes start to operate.

The interval of 1·118 miles may seem long, but the distance can be altered in the light of experience of the route and service conditions. For the particular route where the apparatus was tested 1·118 miles was found to be a suitable distance.

Editorial comment in Weekly Survey.

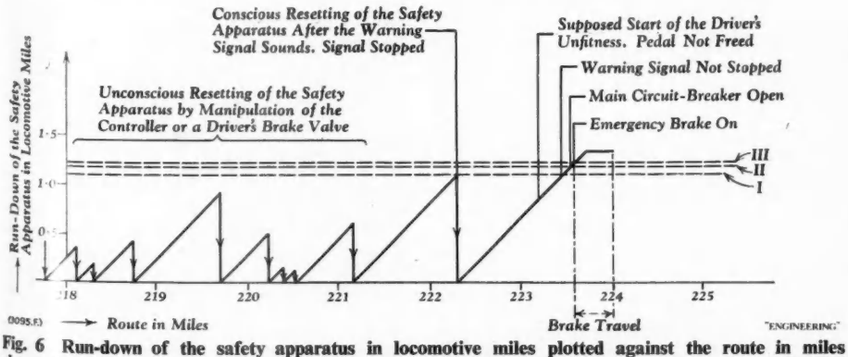


Fig. 6 Run-down of the safety apparatus in locomotive miles plotted against the route in miles shows he device being reset automatically, then reset by hand, and finally operating the emergency brakes after the driver has become unfit.

TITANIUM: I.C.I. IN THE UNITED STATES

Imperial Chemical Industries Limited, Millbank, London, S.W.1, and Columbia-Southern Chemical Corporation, Pittsburgh, U.S.A., have submitted a joint application to the United States Government for a contract under which the Government would undertake, for a five-year period, to purchase 5,000 short tons per annum of granular-titanium metal. In their application to the Government for a contract the two companies have stated that they have completed arrangements for the introduction into the United States of a granular-titanium process not at present employed there and that they would also make available to fabricators techniques not at present known or employed in the United States.

If a contract is awarded in pursuance of their application, Imperial Chemical Industries and Columbia-Southern Chemical Corporation will form a jointly-owned subsidiary for the purpose of producing granular titanium metal by the British Company's sodium reduction process. The parent companies will each hold a 50 per cent. interest in the new company, which would be known as the Columbia Titanium Company. The plant would be built at Natrium, West Virginia, and would have a capacity of 5,000 short tons per annum. The cost of the proposed granular titanium metal plant will be in the region of 10,000,000 U.S. dols.

The patent position and production experience of Imperial Chemical Industries have a broad base through their experience of chemical and metallurgical technology. Their knowledge of patents and processes extends from the production of granular titanium metal by their new sodium process, to melting, scrap recovery, alloying, testing, jointing and fabrication. In fabrication, particularly, they are favourably placed by virtue of their wide experience in non-ferrous metal technology.

Columbia-Southern's contribution to the proposed joint enterprise lies in the production of titanium tetrachloride, from which granular titanium metal will be made. The firm is one of the leading American producers of chemical products and is a wholly-owned subsidiary of the Pittsburgh Plate Glass Company. It has been engaged in research on the chlorination of titanium-bearing ores since 1937, and has established a broad patent position in this field, to-day licensing other companies under Columbia-Southern patents.

The two companies believe that their proposal to the American Government will result in lower capital and production costs and in the acceleration of a titanium-fabrication industry in the United States.

★ ★ ★

LIGHT-WEIGHT AGGREGATE FOR CONCRETE

Disposal of Fly Ash from Battersea Power Station

The Central Electricity Authority and the Cementation Company, Limited, 39 Victoria-street, London, S.W.1, have just completed an agreement whereby the latter will take over all the output of fly ash—some 65,000 tons a year—produced by pulverised-fuel-fired boilers at the Authority's Battersea power station. The ash will be converted into a light-weight aggregate by the "Sinterlite" process developed by Mr. F. P. Somogyi, consulting engineer.

The production in the heart of London of a light-weight alternative to other aggregates which are growing scarce and costly, including gravel which at present has to be brought in some 20 miles or more by road, is of significance to the building industry. From the standpoint of the Authority, this solution to the problem of disposal of fly ash, which commonly involves transportation and dumping on waste land or at sea, is both convenient and profitable.

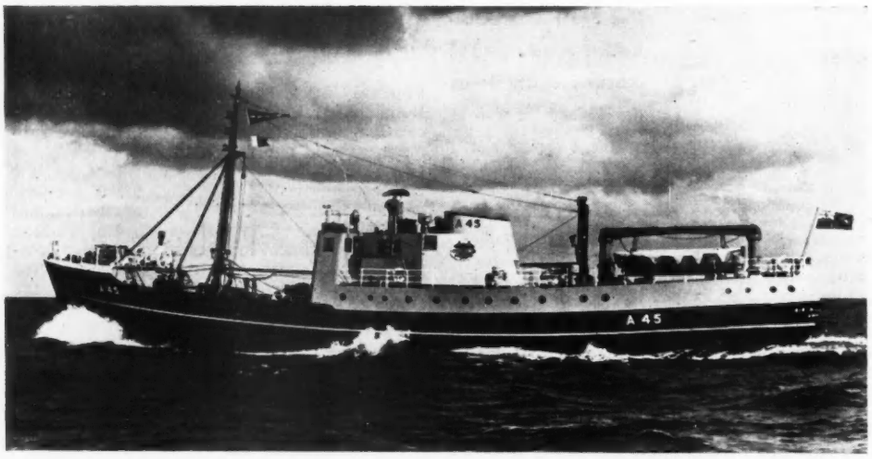


Fig. 1 The trawler "Sir William Hardy" is driven by electric motors supplied from Diesel-electric generators, and is equipped with a laboratory for research on the preservation of fish as food.

FISHERY RESEARCH TRAWLER "SIR WILLIAM HARDY"

DIESEL-ELECTRIC PROPELLING MACHINERY

The fishery research trawler Sir William Hardy, shown in Fig. 1 above and recently completed by Hall, Russell and Company, Limited, Aberdeen, to the order of the Director of Navy Contracts, Admiralty, acting on behalf of the Department of Scientific and Industrial Research, is a vessel possessing a number of unusual features. Not the least of these is her propelling machinery, for she has the distinction of being the first Diesel-electric trawler to be built in this country. Her particular purpose is to carry out research on the preservation of fish as food, for which she is provided with a well-equipped laboratory and with accommodation for four members of the scientific personnel of the Torry Research Station at Aberdeen, to which she is attached, in addition to the normal fishing complement, numbering 16.

The principal dimensions are as follows: Length between perpendiculars, 131 ft.; breadth moulded, 27 ft. 6 in.; and depth moulded, 15 ft. The vessel was built under the special survey of Lloyd's Register and to the highest classification for trawlers. Particular attention has been paid to the insulation of the fish rooms, and, in the forward hold especially, extensive use has been made of aluminium for racks, etc. One of the holds is fitted with an experimental quick-freezing plant, and there is also a liver-oil extraction plant. The accommodation for the crew as well as for the scientific complement is arranged aft. The specification for the ship and equipment was prepared by the Torry Research Station in consultation with the British Shipbuilding Research Association, the Ship Division of the National Physical Laboratory, the Ministry of Transport, the Fisheries Department, and representatives of the fish industry. The vessel was launched on November 29, 1954, the ceremony being performed by Mrs. G. A. Reay, the wife of Dr. Reay, Superintendent of the Torry Research Station; and she ran her trials off Aberdeen on March 30, 1955, when a speed of 11·8 knots was obtained as the mean of two runs on the measured mile. Tests of the fishing and other equipment followed and were completed on June 6, as already recorded in ENGINEERING (June 24, 1955, vol. 179, page 800).

PROPELLING MACHINERY

The main contractors for the propelling machinery were the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. The installation consists of four six-cylinder engines, supplied by Henry Meadows, Limited, Wolverhampton, and rated (on a 24-hours basis) at 200 brake horse-power when running at 1,400 r.p.m., driving, through flexible couplings, Metropolitan-Vickers constant-current generators of 125 kW output (Fig. 2). The Diesel engines are Meadows' DMS970 type and are interchangeable, a fifth engine being kept as a spare so that any one engine can be removed for overhaul without immobilising the ship for more than a brief period.

Each Diesel-generator set is mounted on a combined bedplate carried on Silentbloc flexible mountings, and is fitted with its own fresh-water and salt-water circulating pumps, heat exchangers and oil coolers. The fresh-water circulating systems are thermostatically controlled, and immersion heaters are fitted in the engine sumps so that engines not in use may be kept warm and ready for immediate service. Each engine also has its own instrument panel, with an exhaust pyrometer, pressure gauge and tachometer; and the fuel pumps, which are of the C.A.V. type, incorporate a governor which is set to operate at the normal speed of 1,400 r.p.m., but which can be adjusted to hold the engine speed at 1,000 r.p.m. if it should be required to connect one of the main propulsion generators to the auxiliary busbars.

The propulsion motor is a double-unit machine which delivers 600 shaft horse-power at 200 r.p.m. It is supported in a disc-lubricated sleeve bearing at the forward end and a combined thrust and journal bearing of the Michell type at the after end; the Michell bearing is water-cooled by a shaft-driven pump. The motor is ventilated by duplicate centrifugal fans, drawing from above the deck and exhausting into the engine room, and each capable of supplying sufficient air for continuous operation of the motor at full speed. The motor is watertight up to the level of the shaft. At the forward end of the motor is a belt drive to the speed-limiting and tachometer generators, and there is also a mechanical overspeed emergency switch. There are two exciter sets, each consisting of a 17-h.p. motor, running at 1,500 r.p.m., driving two Metadyne exciters, one of which controls the speed and output of the propulsion motor and the other the constant-current propulsion system. One of the sets acts as a standby unit.

The trawl winch, supplied by Charles D. Holmes and Company, Limited, Hull, is of that firm's standard design and has two barrels, each capable of holding 650 fathoms of 2¼-in. trawl warp, and two 21-in. warping drums, fitted with automatic lubrication. The two driving motors, each of 75 h.p., are mounted below deck in the refrigerator-motor compartment, forward of the engine room. They are horizontal-spindle marine-type machines, and drive through Crofts bevel gearboxes and inclined shafts passing up through the deck to a second drive shaft on the winch. Normally, both motors are used, but clutches are provided to enable either motor to be disconnected if necessary. The motors are of the constant-current type, with governor exciters and forced ventilation, and are designed for a stalling torque of 1½ times the full load; they will withstand this torque for 30 minutes without overheating. The normal full-load speed is about 1,000 r.p.m. and the light-load speed about 1,750 r.p.m. A handwheel regulates the speed of the winch and there is a lever for reversing; and the characteristics of the control gear enable the winch to be operated in exactly the same way as a steam-driven winch would be (Fig 3).

ELECTRICAL SYSTEM FOR PROPULSION AND TRAWLING

The propulsion and trawling circuits operate on the constant-current system, all four generators, the propulsion motor and (when they are in service) the trawl-winch motors being connected in a series loop through which passes a constant current of 500 amperes. A generator Metadyne exciter supplies all the generator fields in parallel and regulates the excitation so as to maintain the current at a fixed level, the output voltage of the generators being varied to suit the power demand. On full load the maximum voltage is 1,080, and the arrangement is such that the voltage to earth never exceeds 540. Any generator can be cut in or out of the circuit by means of its transfer switch, which is interlocked with its respective field switch.

The propulsion motors being supplied with constant current, the torque can be controlled in magnitude and direction solely by controlling the excitation. To reduce the control currents to a small value, a Metadyne exciter is used to supply the fields and the bridge or engine-room controller operates directly on the field of this exciter. This method enables overspeed control of the propulsion motor to be effected very easily and automatically reduces the power when any engine is cut out of service. The winch motors are similarly controlled, except that the

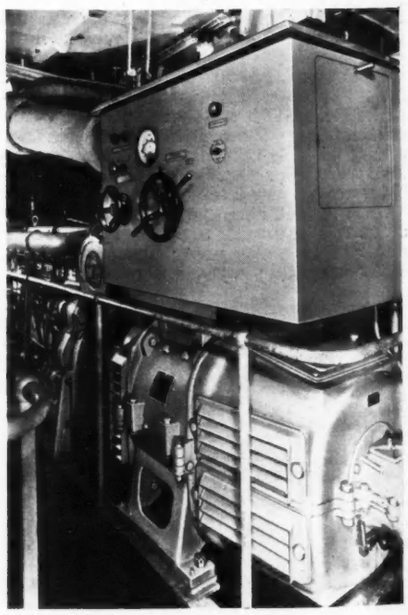


Fig. 2 One of the four Diesel generator sets, driven by a 200-b.h.p. engine and giving a constant-current output of 125 kW.

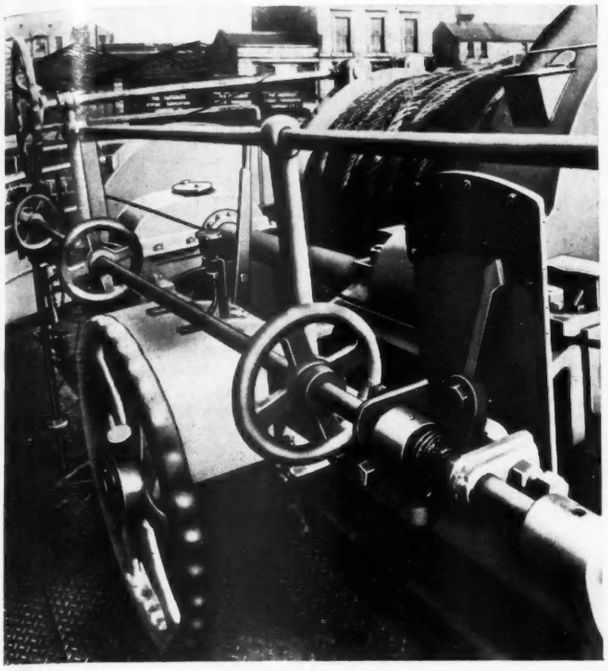


Fig. 3 The winch control gear, showing the speed regulating handwheel and the reversing lever.

field current is supplied directly through a reversing potentiometer, speed limitation being obtained by means of a directly-coupled governor-exciter acting in opposition to the field supply.

Normally, the ship is handled from the bridge by means of a combined controller and bridge telegraph consisting of a Robinson pedestal in the starboard wing. It is of the twin-screw type, specially modified to meet the requirements of the method of propulsion. The controller is mechanically coupled by shafting to the two handles on the telegraph pedestal, one handle operating the normal controller and having five notches ahead and astern, and the other a vernier controller which gives ten intermediate speeds between notches. Mounted in the controller head is a propeller-speed indicator and also a reply telegraph for use when the machinery is being handled from the engine room. In this latter case the propulsion motor is operated by means of a handwheel, on the front of the control desk, which is mechanically connected to a controller similar to that fitted for bridge control. Also grouped on the control desk are a change-over switch between the bridge and engine-room controls, a Metadyne change-over switch, and the telegraph indicators, counters, voltmeters and ammeters, etc.

AUXILIARIES

Current for auxiliary purposes is supplied by two Diesel-driven generator sets consisting of Meadows engines (identical with those used for propulsion) driving level-compound generators, each delivering 135 kW at 220 volts. For the supply of starting air for the main and auxiliary Diesel engines there is an electrically-driven Hamworthy two-stage compressor which will compress 9 cub. ft. of free air per minute to 450 lb. per square inch. As a standby there is a small compressor, also Diesel-driven, with a capacity of 6 cub. ft. per minute, delivered at the same pressure. Of the four air receivers, each of 5 cub. ft. capacity, one is fitted with a reducing valve to supply air at 100 lb. per square inch for use in the laboratory and to operate the whistle. Two Drysdale 2½-in. vertical centrifugal pumps, driven by 5-h.p./7-h.p. motors, are fitted for bilge pumping and general service; and there is a Drysdale fuel-transfer pump with a capacity of 2 tons per hour. The fuel-oil purifier of De Laval make, has a throughput of 150 gallons per hour; it is provided with an electrical heater. A 9-kVA motor generator set supplies alternating current for the laboratory. All this equipment is controlled from an auxiliary switchboard on the after engine-room bulkhead. Parallel operation is not used, but the board has duplicate busbars connected to the two auxiliary generators. Provision is also made to connect a shore supply to either busbar and, as previously mentioned, to connect any of the main propulsion generators to one of them, to give up to 40 kW.

LABORATORY

The laboratory is fitted out with teak benches, beneath which are drawers and cupboards. Above the benches are the necessary racks, pegs and partitioned shelves to hold the equipment of instruments, bottles, glassware, etc. Salt water is supplied from a pressure system feeding taps and ejector pumps, and fresh water from a gravity tank to other taps and to an electric immersion heater fitted over a stainless-steel sink. A closed drainage system collects the waste water. Connections are also provided for compressed air and for Calor gas. The electricity supply to the roof and bench lights and to various sockets is by direct current at 220 volts, but additional sockets are provided for single-phase alternating current at 250 volts and 50 cycles, supplied by the motor generator previously mentioned. Miscellaneous equipment includes a fume cupboard with an electric extractor fan, a combined incubator and oven, a refrigerator, and a 12-volt accumulator charging board. A hatch in the deck affords direct access to the refrigerated compartments and the fish holds, and provision is made for automatically recording in the laboratory the temperatures of fish kept under experimental conditions in these compartments. The equipment of the laboratory was all supplied by Baird and Tatlock, Limited, London.

NAVIGATIONAL EQUIPMENT

In addition to the trawl winch, there is an anchor windlass and a warping capstan both electrically operated; and the vessel is equipped with all the usual navigational instruments and apparatus, including a gyro-compass, the whole of which, with the exception of the Decca Navigator, was supplied by Messrs. Marconi. Among the sub-contractors may be mentioned J. and E. Hall, Limited, Dartford, who supplied the refrigerating plant, including the Torry-Hall vertical-plate freezers; and the J.D. Insulating Company, Limited, who were responsible for the insulation of the fish holds.

* * *

REINFORCED-PLASTICS FIRE HOSE

The British Tyre and Rubber Company, Limited, Herga House, Vincent Square, London, S.W.1, are commencing production of a new type of fire-fighting hose, known as Plastidry. Light and flexible, it consists of a tough plastics inner tube and outer cover enclosing and protecting a strong synthetic fabric reinforcement, the latter being completely embedded in a homogeneous plastics mass. Thus the fabric is never wetted and Plastidry therefore never needs drying. It can be stored indefinitely without deterioration. Plastidry is immune to oils, acids, and alkalies. The bore is very smooth, so that the hose delivers 60 per cent. more water than canvas hose and 10 per cent. more than rubber-lined hose. The plastics cover is further protected by an abrasion-resistant outer surface, which prevents damage when the hose is dragged over rough ground.

Plastidry is in regular service with the NATO naval and civil defence forces and fire brigades in France, Belgium, Holland and other European countries. The British Tyre and Rubber Company are the exclusive manufacturers in the United Kingdom and Commonwealth.

* * *

INDUSTRIAL AND TECHNICAL EDUCATION

A conference on technical education was held in April by the Regional Advisory Council for the Organisation of Further Education in the East Midlands and the F.B.I. North Midlands Regional Council. An interesting report of this conference has now been published by the F.B.I. It was divided into two sessions: one dealing with the relation between part-time, full-time and sandwich courses; and the other with co-operation between industry and technical education. There was agreement that, although the number of students attending technical courses is far greater than before the war, there are still not enough young people continuing their education after leaving school. This is largely due to wastage within a few months of leaving school, while the boy is waiting to begin an apprenticeship. The influence of too high wages for boys of 17 or 18 in removing the incentvie for further education was also mentioned. The provisions made at evening institutes for young people to continue their education before beginning an apprenticeship and technical college studies was not sufficiently widely known.

Air Commodore W. C. Cooper stressed the importance of development of the " production sense " in those going in for this branch of work. He had come to the conclusion that for technologists and technicians going in for production, full-time technical education, even when supplemented by industrial experience during vacations or initial and post-graduate years, does not satisfy the specification which industry requires. The day-release course could not provide sufficient technical knowledge and the only alternative was the sandwich course. However, he preferred alternating periods of six weeks to the usual six months college six/months industry approach.

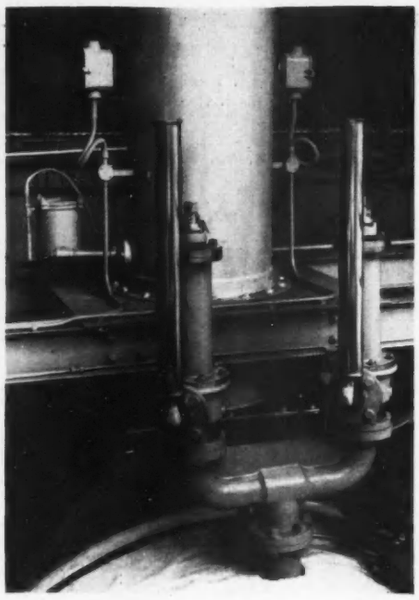
The ideal would be an industrially based " residual " (presumably a misprint for " residential ") training in industrial colleges specifically created for the purpose. This had been successfully practised for many years in the fighting services.

* * *

ORPHEUS TURBOJET

Last week the United States Department of Defense announced that, under mutual agreement, a grant of 4 million dollars is to be made to the United Kingdom for the development of the British Orpheus turbojet which is to power two French light-weight tactical fighter aircraft, the Breguet Taon 1001 and the Dassault Mystère XXVI, three prototypes of each of which have been ordered for evaluation by NATO. The United States is contributing 5 million dollars to France for the development of these two aircraft.

Another 2·3 million dollars has already been allotted to Italy for the development of 27 Fiat G.91 light fighter aircraft to be built for tactical trials. This aircraft also is to be powered by the Bristol Orpheus.



The light-ray projector and photo-electric receiver are mounted on opposite sides of the stack to monitor the flue gases. This smoke control device is designed for use in conjunction with the secondary air flaps in medium-sized industrial boilers.

SMOKE CONTROL IN A MEDIUM-SIZED BOILER

Controls to reduce smoke emission and increase efficiency of combustion in medium-sized industrial boilers have been tested on a single return economic boiler by the Ministry of Works at the Home Office Stores, Watford.

In common with many industrial plant engineers the Ministry of Works Engineer-in-Charge was faced with the problem of complaints of excessive smoke emission which was accompanied by waste of heat through loss of combustible products to the atmosphere. In large power stations and steam raising plants it is economically possible to fit an elaborate range of instruments and employ a full-time qualified engineer. The Watford installation, however, warranted only a minimum of instruments and is the type of plant which receives only periodic technical supervision, the day-to-day operation being in the hands of the stoker. For these reasons the answer to the problem had to be simple and positive.

To reduce smoke emission the Ministry of Works adapted and fitted smoke-eliminator doors to the boiler. Full instructions were given to the fireman on the correct operation of the door in relation to the firing cycle, these being based on a time period. This was a step in the right direction and achieved a significant degree of smoke elimination, but the procedure was not ideal because the cycle of operation varied with the type of fuel being burned. The sequence of operation of the door could not be related to fuel variation, fuel thickness on the hearth and the quantity of secondary air introduced, and it was possible for the secondary air flap to be closed too soon resulting in a resumption of smoke generation.

The final solution was found by fitting smoke density measuring equipment made by Radiovisor Parent Limited, 1 Stanhope-street, London, N.W.1, and using the alarm device in conjunction with the secondary air flaps. The equipment consists, essentially, of a light-ray projector and photo-electric receiver with a control unit; facilities are provided for adjustment of the smoke level at which the alarm is energised and it is so designed that it is readily adapted to various sizes of stack. The projector and receiver, mounted on the up-take in the manner shown in the illustration, monitor the flue gases continuously. Before it is discharged from the stack, smoke generation on the hearth causes the warning bell to ring, and the secondary air to be adjusted.

A standard procedure has been adopted by the firemen whereby, immediately after refuelling, the secondary air flaps on the smoke eliminator doors are opened and left for a short period. Additional air enters assisting complete combustion of the volatiles emitted from the newly-fired coal. After the period of time has elapsed the secondary air flap is closed and the photo-electric smoke density unit checks the flue gases and sounds the alarm if smoke is present, indicating that combustion of the volatiles over the hearth is not complete. Under these conditions the secondary air flap is re-opened for a short period and then closed again.

* * *

GENERAL-PURPOSE MACHINE TOOL

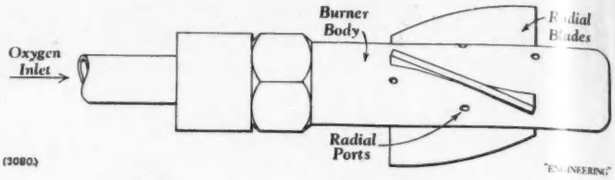
In tool rooms and the smaller workshops it is uneconomical to install a large number of specialised machine tools which only have occasional use and have a high initial cost. A generalised machine that could be converted into the type required would evidently seem to be a better proposition, and such a machine, the " Universal Rindis " is now being made by Lavant and Company, Limited, 98-100 Croydon-road, London, S.E.20.

As may be seen from the illustration, it consists basically of a motorised head-stock and adjustable work table, together with a large number of accessories which can be attached to the former (55 are listed in the catalogue). With these accessories and the built-in gearbox, an enormous number of different operations can be carried out.

Contained within the main pedestal are the main driving motor, the suds tank and the suds pump. The motor is of 1½ h.p. in standard machines, but can be replaced by one of 2 h.p. if desired. The drive is taken to the spindle in the head by an arrangement of V-belts and pulleys which allows 18 different speeds to be obtained ranging from 75 to 2,600 r.p.m. By including an additional pulley, the range can be extended to include 2,800 and 3,400 r.p.m. A patent tensioning device is included. The main spindle is of heat-treated nickel-chromium steel and is registered to take collets up to 1 in. in diameter. It can be locked by the knob mounted on top of the head. With this range of speeds, such operations as disc-filing, milling and grinding can be carried out, and the required tools are included in the accessories available. The attachment for vertical milling has a head which can be swivelled through 180 deg. and has a graduated scale on it. This attachment can also be used for jig-boring.

The table measures 17½ in. by 6½ in. giving an actual working area of 12½ in. by 6½ in.; it can be turned through 360 deg. The longitudinal traverse is 8 in., transverse is 6 in. and the vertical movement also 6 in. Large-diameter micrometer dials are calibrated in steps of 0·001 in., and rapid longitudinal traversing can be made using a hand lever. The light is supplied from a built-in 12-volt transformer. All the control switches are mounted on the side of the pedestal and there is a four-pin socket for supplying power to the attachments. Dimensions of the machine are 41 in. by 26 in. by 56 in. and the weight approximately 9½ cwts.

This burner is used for cleaning out pipes fouled by tar deposits. The fins space the burner from the pipe walls and to some extent act as scrapers.



FLAME CLEANING OF FOULED TUBES

A method of cleaning out tubes fouled by tar deposits has been developed by the British Oxygen Company, Limited, and has been tested by the Prince Regent Tar Company. The tubes involved were still tubes used in the coal-tar distillation process. In service these tend to become fouled by deposits of bitumen; cleaning is normally done with a mechanical drill and scraper, and can be a long and tedious job. Use of the apparatus developed by British Oxygen materially reduced cleaning time, in some cases from one day to 30 minutes. The still tubes to be cleaned were of cast iron, 15 ft. in length and 2 in. bore. A simple burner was designed with integral fins, as shown in the illustration. The fins spaced the burner from the walls and also acted to some extent as scrapers.

During tests it was noticed that at one stage of heating the gummy bitumen turned into a form of powdery coke, which was easily removed by scraping. The burner was subsequently made with only a few $\frac{1}{16}$-in. holes drilled in it for gas nozzles, and these were sufficient to bring about the required conditions. The assembly was attached to an ordinary piece of lance tubing through which the gases were supplied, and it was then possible to push the assembly progressively through all the obstructions. Alternate passes with this burner and a scraper proved adequate to remove all deposits. To avoid damage from heat the burner was made of stainless steel.

Over 50 accessories make the " Rindis " into a versatile machine tool for the small factory.

BRITISH ASSOCIATION MEETING AT BRISTOL

SELECTED PAPERS TO BE PUBLISHED IN "ENGINEERING"

An unusually large number of engineering papers are to be presented at the annual meeting of the British Association for the Advancement of Science, which is to be held at Bristol from August 31 to September 7. The titles and authors of these papers are given in the list below, and most of the papers will be published in September issues of ENGINEERING.

This year's President of the Association, Professor Sir Robert Robinson, O.M., F.R.S., will deliver his address, on "Science and the Scientist," on the evening of Wednesday, August 31. The President of Section G (Engineering), Dr. S. F. Dorey, C.B.E., F.R.S., will speak on "The influence of the engineer on sea transport and trade" on Thursday morning, September 1. The Recorder of Section G, as in recent years, is Professor W. Fisher Cassie.

The three evening discourses this year are on "Experiments at great heights with free balloons" by Professor C. F. Powell, F.R.S. (September 2); "Scientific and dramatic modes of thought," by Professor H. D. F. Kitto (September 4); and "Stonehenge in the light of recent research" by Mr. R. J. C. Atkinson (September 5). There will also be an evening lecture on "The living past" by Professor David Douglas, as well as lectures for young people on "The scientific work of the British North Greenland Expedition," by Mr. R. A. Hamilton, and "Man's influence on the weather," by Mr. B. J. Mason. Other attractions include several exhibitions, scientific films, and visits to factories, etc.

Members of Section G (Engineering) will be the guests at a Conversazione to be held at the University Engineering Laboratories on September 5. The hosts will be the western branches of the Institutions of Civil, Mechanical and Electrical Engineers, the Royal Aeronautical Society, and the Faculty of Engineering.

The 1956 meeting of the Association is to be held in Sheffield from August 29 to September 5, and the 1957 meeting in Dublin.

SECTION G (ENGINEERING)

Thursday, September 1 (Morning):

"The influence of the engineer on sea transport and trade," Presidential Address by Dr. S. F. Dorey, C.B.E., F.R.S.

"The influence of space flight on engineering and science," by M. W. Rosen.

Friday, September 2 (Morning):

SESSION A:

"Model research and its application to ship design," by Dr. R. W. L. Gawn.

"The scientific development of modern locomotive designs," by J. S. Tritton and J. C. C. Paterson.

SESSION B:

"The methods of using fuel in a nuclear power programme," by Dr. J. V. Dunworth.

"The design and operation of power-producing reactors," by H. H. Gott.

Monday, September 5 (Morning):

SESSION A:

"Motorways," by J. A. Proudlove.

"Motor vehicles and design," by J. N. McHattie.

SESSION B:

"The linear acceleration of charged particles to high energies," by C. W. Miller.

"Circular accelerators for nuclear particles," by Dr. J. B. Adams.

JOINT SESSION WITH SECTION C (GEOLOGY):

"Geology and site investigations," by F. H. Edmunds.

"The fundamentals of soil mechanics," by P. L. Capper.

"Soil mechanics and railway civil engineering," by A. H. Toms.

"Soil mechanics aspect of the design of foundations," by F. D. C. Henry.

Tuesday, September 6 (Morning):

SESSION A:

"Recent progress in British air transport," by Peter G. Masefield.

"Effects of turbine engines on civil air-transport design," by Dr. W. J. Strang.

SESSION B (PAPERS BY YOUNG ENGINEERS):

"The effect of leakage on compression and expansion in a non-flow process," by D. L. Brook.

"Collapse tests of Vierendeel Trusses," by S. Henderson.

"A mathematical and photoelastic investigation of the stress distribution under foundations," by Dr. J. E. Gibson.

"Constraint effects in box beams," by D. Howe and K. H. Griffin.

HIGH-ALTITUDE ROCKET RESEARCH

The Royal Society Statement

The following statement on the United Kingdom's plans for high-altitude rocket research in the earth's upper atmosphere was published in London by the Royal Society on August 3.

"The wind, temperature, humidity and other properties of the atmosphere up to heights of about 200 miles can be studied directly by means of instruments carried up by free balloons. Observations of this kind are regularly made by meteorological services throughout the world. Although the atmosphere at greater heights is very tenuous it necessarily plays an important part in many phenomena. Thus long-distance radio propagation is only possible because of the existence of reflecting layers, known as the ionosphere, at altitudes of 60 miles and above—indeed a very important region extends upwards from a height of 90 miles. Meteors are mainly evaporated at the 60-mile level and the aurora, at least in high latitudes, is located at about the same level. The electric currents which give rise to the variations of the earth's magnetic field circulate in this region and it is also the seat of a night time air glow quite distinct from the aurora or the light of moon and stars.

"Before the war information about the upper atmosphere could only be obtained by indirect methods. The remarkable developments of rockets as weapons led to the possibility of carrying instruments into the upper air in vehicles of this kind. This was first achieved in the U.S.A. in 1946, using captured V2 rockets. Since that time steady progress has been made and many interesting results have been obtained. The greatest height reached so far has been 240 miles.

"A research programme of this kind is expensive and until recently was exclusively carried out by American scientists and technicians. It is very desirable that work should be carried out in other countries, to obtain data under different conditions and locations and employing different techniques. A programme has already been commenced in France and an extensive programme is now being initiated in the United Kingdom through the co-operation of the Ministry of Supply, particularly the Royal Aircraft Establishment, and the Gassiot Committee of the Royal Society. The programme aims at having available within two years, rockets able to carry 100 lb.wt. of scientific instruments up to heights of 120 miles or more. The design, development, supply and firing of the rockets will be carried out by the Ministry of Supply. Five University research groups, from University College, London (Professor Massey), the University of Birmingham (Professor Sayers), the Queen's University of Belfast (Professors Bates and Emeleus), the University College, Swansea (Dr. Beynon) and Imperial College, London (Professor Sheppard), will be initial participants in the scientific programme. The work will be co-ordinated through a special sub-committee of the Gassiot Committee of the Royal Society. The first experiments will include determination of atmospheric temperature and density, the study of the nature of the ionosphere, a search for very fine meteoric dust below 60 miles altitude and determination of the heights of the regions from which the night airglow is strongest. While the development of the rockets is proceeding, work on the scientific instruments required will proceed in parallel, so that both should be available at nearly the same time.

"Although this programme has been arranged independently of the International Geophysical Year it is hoped that it will be in operation during this period and add substantially to the British contribution to the Year."

★ ★ ★

RADIO-ASTRONOMY AT CAMBRIDGE

Mullard's Offer to the Cavendish Laboratory

The University of Cambridge has received from Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2, an offer to provide over a period of ten years the sum of £100,000 for the purpose of continuing and extending the work in radio-astronomy which is in progress in the Cavendish Laboratory. With this benefaction it is intended to set up a new observatory to be known as the Mullard Radio-Astronomy Observatory. It is hoped that a site near Cambridge will be available for this purpose and that it will enable a number of observations to be made which have not yet proved to be possible.

Important work in radio-astronomy was started soon after the war both in Cambridge under Mr. M. Ryle and in Manchester under Professor A. C. B. Lovell. At Cambridge special types of radio-telescope have been developed and used for detecting the astronomical bodies known as radio stars and for special investigations of the sun. With the instrument which is now in use in Cambridge it has been possible to detect and to measure the radio waves from nearly 2,000 such stars, and the results suggest that many of these are at distances greater than those of the most-distant stars observable with optical telescopes. At the new site, and with the help of a new radio telescope, observations could be made of radio stars beyond the reach of the present instrument. It is also proposed to install a number of smaller instruments designed for special purposes.

The investigations which will be made at the Mullard Observatory will be largely complementary to those for which a different type of equipment, the large paraboloid radio-telescope at Manchester University, is best fitted. (A description of the Manchester telescope, the construction of which was then just commencing, together with a brief account of the work to be undertaken, was given in our issue of June 25, 1954; on page 826, vol. 177.) The combination of the two different types of instrument will be important in maintaining the present lead of the United Kingdom in this new field of astronomical research.

Labour Notes

AGENDA FOR THE T.U.C.

Strikes, inter-union disputes and automation are the main headings of the preliminary agenda for this year's Trades Union Congress to be held in Southport from September 5 to 10. Twenty-six of the 82 resolutions tabled relate to questions of trade union organisation and practice and, in general, the emphasis on internal and industrial problems is more marked than it has been for many years. Opposition to any attempt to limit the right to strike by legislation is expressed in four resolutions, although this possibility was virtually ruled out by general agreement of the National Advisory Council recently (Labour Notes, August 5). The T.U.C. general council are to be asked to amend their rules to enable them to intervene in future stoppages, not merely when deadlock occurs but when it seems probable. Inter-union conflicts have made a deep impression on the movement, and there are suggestions for reviving an old scheme for trade union organisation industry by industry, and another for an integrated trade union movement in each of the nationalised industries. Only four resolutions this year are concerned with proposals for more nationalisation.

The more important debates at the congress take place on the General Council's report, but resolutions from members are a useful barometer of opinion. For example, on inflation there is a demand for stricter control of profits and dividends; on wages and working hours, a call for equal pay and a 40-hour week with a reduction of systematic overtime; on automation, a request for more information and a study of the "new and complex human, social and economic problems" likely to arise. But the nation's main problem, the urgent need for more exports and less home consumption, does not so far appear to have intruded on the collective consciousness of the movement.

THE MINERS AND FOREIGN LABOUR

The shortage of manpower in the coal mining industry is once again threatening a national crisis and, so far, the National Coal Board's recruitment campaign has done little more than slow down the rate at which men are leaving the pits. During the twelve months to July 23, the industry's labour force declined by 3,400 workers to 702,700. Estimates of the number of men the industry needs this year if the pits are to be fully manned vary from 15,000 to 20,000. The President of the National Union of Mineworkers, Mr. W. E. Jones, told delegates at the annual conference of the Union last month that: "With 17,000 more men we could produce 5½ million more tons of coal and save the nation between £30 million and £40 million of foreign exchange."

At the N.C.B's request, leaders of the N.U.M. met last Friday to discuss the situation, and in particular the possibility of recruiting men in Italy and Austria. We understand that, to avoid an open clash in the full executive between those who advocate the use of foreign labour and those who are opposed to it, they decided to refer the matter to their economic committee, consisting of the president, the vice-president, the general secretary and three executive members. The committee were asked to make "an extensive inquiry into the recruitment, use and wastage of manpower in the industry."

Those who oppose the recruitment of foreign labour argue that it is a stop-gap measure and that the N.C.B. could easily solve its labour shortage by paying higher wages and raising the miners' status. Whether this is correct or not, and there is much to suggest that it is an over-simplification of the problem, there is no doubt as to the hostility with which the lodges view the importation of foreigners, particularly in Yorkshire and South Wales where, with the West Midlands, the shortage of men is most acute. In 1951, a scheme to import 5,000 Italians, supported by the Government and by the N.U.M. executive and accepted by many lodges, foundered upon local opposition when the men arrived, and about half the 2,000-odd who came could not be found jobs in coal mining. Small wonder therefore that the N.U.M. are treading gingerly, and that the N.C.B. will not move without the miners' full approval.

WIDER ISSUES IN COALMINING

The drain of manpower from the mines, the hostility of the lodges to imported labour, and many management problems encountered since the war are not, as some will have it, due to cussedness and greed on the part of the miners or to mischief-making on that of their leaders. As a body they have a fine record of patriotism and devotion to duty and a long tradition of comradeship. It is in the changes that have taken place over the past decade or two in the conditions in which they work, and of course in the long and bitter experience of unemployment in the inter-war years, that the roots of the present troubles are probably to be found.

The number of those still at the coal face who have personal memories of the general strike, or of the slump of 1930, becomes smaller, but many still talk of those days, particularly the old folk in the villages. The industry has a tradition of insecurity, of harsh working conditions and of tough employer-employee relations. Young men have been leaving the mines or not going into them. Here therefore may be a good place to inject security into employment: the annual guaranteed wage may achieve far more than baths at the pithead or a bulging pay packet on a Friday. It is significant that the N.U.M. appointed their economic committee to discuss "questions affecting the future of the coal industry, including the effect of increasing use of fuel oil and the expected application of atomic energy."

Another deep-rooted though more recent cause of instability may be found in the changes brought about by intensive mechanisation. Before the extensive introduction of coal cutting and loading machinery and conveyors, teams of four to six men worked a strip of face about 50 yards long approached by a short by-road from the main roadway, and were responsible not only for getting the coal but for loading it, for moving it back to the main roadway and for maintaining the by-road. The division of labour was left to the men themselves, and payment was clearly related to effort. The new methods call for three large groups of perhaps 30 men, each working a separate shift: the first cut the coal, the second load it on to conveyors, the third move up the conveyor belt and other machinery and put in roof supports. The groups are too large for the team spirit to be preserved. The work is more monotonous and the team is denied the satisfaction of completing a task for which it alone is responsible. These are some of the factors that make up the problem of the mines, all simply but deeply human.

DRIFTING LABOUR

Lancashire cotton mills continue to lose labour at a rate four times as high as the coal mines: already this year 10,000 have left the spinning mills and the exodus shows no signs of slackening. The Cotton Board announced that in all but two weeks this year manpower wastage exceeded recruitment. Both employers and trade unions are very concerned since the drift of labour, while not painful when trade is slack, could make a recovery impossible. Most of the industry's losses are believed to have been to engineering, chemical and paper concerns now thriving in Lancashire.

Yet in the Leicester-Nottingham district, where full employment is at its fullest and where engineering is a fast growing section of manufacturing industry, the losses by the hosiery, lace, rayon and nylon trades have been insignificant. One reason is believed to be the extensive recruitment of women: the proportion in hosiery and knitwear is nearly 72 per cent. whereas women account for less than two-thirds of the cotton mill labour force. In a more energetic recruitment of women therefore, providing if necessary nurseries for children at the factories, may lie the solution to Lancashire's labour problem.

RIFT ON THE COPPERBELT

African advancement, as it has become known, is an issue around which there has been much bitter controversy on the Northern Rhodesian Copperbelt and on which the two groups of mining companies operating in that area—Rhodesian Anglo-American Limited and Rhodesian Selection Trust—cannot agree. The proposal, which is supported by R. S. T., is for the transfer to the African schedule of a good many jobs now restricted to members of the European Mine Workers' Union. Just when agreement between the two groups appeared likely on the immediate desirability of African advancement, Anglo-American signed an agreement with the Union which, according to their chairman, Sir Ernest Oppenheimer, would have the effect of transferring during the next three years various categories (24 were mentioned) of jobs from the European to the African schedule, provided the white union agreed. During the period of the agreement a firm of independent industrial consultants, employed jointly by the companies in the group and the union, would carry out an analysis of each job on the European schedule. At the end of the period the companies and the union would meet again to decide on further action.

Selection Trust have objected strongly to the agreement, which they say means that "no single African can advance unless the European union first agreed." They point out that the granting of the veto to white workers in this instance invites similar requests from white workers on the railways and in other industries. This, R.S.T. argue, would reproduce the South African racial pattern and would give the white unions control of the Federation's industrial, economic and racial future and would mean "the complete destruction of the Federation's partnership ideals." If the R.S.T's negotiations with the union founder on the issue of the veto—their chairman, Mr. R. L. Prain, has already declared his readiness to compromise by agreeing to a substantial reduction in the number of jobs he wanted transferred to the African schedule—the dispute between R.S.T. and its white employees will doubtless be referred to the Governor for arbitration.

CIVIL SERVANTS' PAY RISE

The award of a 5 per cent. pay rise to 400,000 civil servants and about 190,000 Post Office workers by the Civil Service Arbitration Tribunal was clearly not expected by the Treasury, who had appealed to the Tribunal to reject the claim. From the point of view of the Chancellor of the Exchequer the award was most unfortunately timed. Shortly before, Mr. Butler had made a statement to the House on the new measures taken by the Government to reduce home consumption and to increase exports, in which he announced his intention to trim Government spending. At about the same time bank managers received instructions to reduce their clients' overdrafts and a sharp fall in gold reserves brought home the precariousness of the balance of payments position. But a wage spiral is difficult to arrest, and on grounds of equity the Treasury had not a leg to stand on.

The claim, submitted two months ago, was for a 7 per cent. increase—the amount by which the general level of wages and salaries had risen since the civil servants' last pay increase in July, 1954. The Treasury rejected it on the ground that no claim could be considered until the end of the year, when the Royal Commission on civil service pay and conditions are due to submit their report. This will be awaited with considerable interest. Government departments are finding it increasingly difficult to retain and to recruit executive grades, particularly technical men, in competition with industry. There is much to be said in favour of paying civil servants well and thus help to maintain a standard of public service that is the envy of other nations.